Born April 14th 1827 [illegible]
on board Brig [illegible] [illegible]
Accra 16th

[illegible]
[illegible]
[illegible]

[illegible]

[illegible] ommenca [illegible] [illegible] [illegible]

[illegible] [illegible] [illegible]

Entry Done [illegible]

[illegible]

[illegible] collected [illegible]

[illegible] 18 [illegible]

[illegible] [illegible] [illegible]

A. D. [illegible] 10 [illegible]

[illegible]

if
veri

Brig Monroe, on coast of
Africa, Young [illegible] Master
Don't Steal it be ashamed of
books, are my name on it

Ever [illegible] of [illegible]

1826.

J. [illegible],

The Proprietor of this Book
James Young is much Teazed out
with the Persons for taking
the Liberty of deforming his Books
by Scribbling. He wishes that such
a Person without Troubling him any

Young Man's best Companion.

W M Craig delt   Published by T Kinnersley Sepr 1 1814.   T Wallis sculpt

BUNGAY EDITION.

THE

YOUNG MAN'S

BEST COMPANION

AND

GUIDE TO USEFUL KNOWLEDGE.

BY JOHN DOUGALL, A. M.

CHOOSE THAT PATH OF LIFE WHICH IS THE MOST EXCELLENT, AND HABIT WILL RENDER IT THE MOST AGREEABLE.

BUNGAY:

PUBLISHED BY T. KINNERSLEY: PRINTED BY BRIGHTLY AND CHILDS.

Entered at Stationer's Hall.

1815.

THE

YOUNG MAN'S BEST COMPANION

AND

GUIDE TO USEFUL KNOWLEDGE.

PREFACE.

CONCERNING the importance and indeed the necessity of education and instruction in general, one opinion alone has been expressed, by men of enlightened understandings and of virtuous and beneficent dispositions, in every age of the world. In no quarter of the globe however, and at no epoch have the benefits of education been more justly appreciated, nor more extensively perceived than in these islands, and at the present time. For these signal benefits and advantages various causes might be assigned: but it is to the liberal and manly spirit of the religious systems we profess, and of the political constitution under which we live, that the advantages we enjoy are principally to be ascribed.

In preparing for the public eye the following work, it has been the purpose of the proprietor, and the study of the editor, to present to the reader, within a moderate compass of size and expense, a general introduction to knowledge, founded on accurate principles, and applicable to various businesses and occupations in ordinary life. In the execution of this design it has been deemed adviseable to deviate, in some material points, from the mode generally adopted in the composition of similar works. Cases do certainly occur, and instances may certainly be produced, of persons who, by mere mechanical address and imitation, have acquired great skill and reputation in important parts of science as well as of art. Such proficiency was certainly neither founded nor acquired on genuine scientific principles. Prodigies of this kind may justly excite our admiration, and stimulate our ambition: but this is not the way nor the process by which the great body of mankind attain knowledge and celebrity. The youth who, disdaining to follow the lengthened and arduous path, which conducts the traveller up the mountain of knowledge and truth, should attempt at once to bound from its base to its summit, would speedily convince the world that he was equally devoid of common understanding as of the talents and genius of the model of his pretended imitation.

For these considerations it has been resolved to lay before the

reader of the present work, in plain, direct, and intelligible language, not only the rules and practices peculiar to each branch of instruction, but in a special manner the original facts, principles and maxims on which those rules and practices are established. Care has besides been bestowed on the explanation of every expression or word, of which the meaning might not be obvious to the generality of readers. Dictionaries of arts and sciences are not always at our command: nor are we always disposed to interrupt our course of reading, for the purpose of consulting them. The consequence is that many a reader may rise from his book, with a charge of words of which he has no distinct conception; and that he is in danger of imagining himself acquainted with the nature and properties of things, while in fact he has only amassed a number of their names.

In elementary publications on the general principles of instruction, little novelty in the matter they contain can, at this late day of the world, be expected: it is therefore in the propriety and completeness of distribution of the several subjects, in the plainness and perspicuity with which each is handled, and in the aptness with which each is illustrated and applied to the purposes of life, that a work of this sort can found any claim to public favour. Utility in its legitimate signification ought to be the object of every work professing to instruct: but with utility entertainment is perfectly compatible. These purposes have therefore been combined in the following pages; taking special care however that the useful shall never become subordinate to the agreeable.

That persons who have made some progress in life, without the advantage of much education, are consequently to be considered and treated as deficient in understanding, in fact as overgrown children, is an opinion but too generally entertained. It is nevertheless equally unfounded in practical life, and insulting to the objects of it. In the present work the reader, whatever may be his station or his acquirements, is beheld with much more respect: he is regarded as not only willing but desirous and able to learn; and on this consideration pains are taken, not merely to tell him what he is to do, but why he is to do it: he has not only the practice, but the origin and principles of each branch of knowledge, with their application and utility in business, laid before him.

By attention to knowledge when conveyed in regular systematic order, we acquire not merely the knowledge there conveyed, but also a matter of far higher importance. We learn to think and reason on rational grounds, and in that particular order by which our progress is at once facilitated and secured. It is in this point of view that an introduction to general knowledge, or even the instructions of a living teacher, can be rendered the most serviceable to the student. From these he may learn the first principles and properties of any branch of science or art; its divisions and uses, primary and subordinate. It is however, only by stedfastly pursuing the path pointed out to him by his instructors, into all its variety of tendencies and objects, that the student can hope to acquire a stock of information, sufficient to enable him to acquit

himself in life with credit and comfort to himself, or with advantage to his fellow-creatures.

Of the nature and distribution of the present publication an idea may be formed from the following table of contents. With respect to the selection of subjects it must be sufficient to say, that those introduced seem to be the best adapted for the generality of readers, in the British public; and few readers will be found who, although they have no direct call, will have no curiosity at least to inquire into the nature of sundry departments of knowledge, *hitherto unnoticed* in similar works, and indeed confined to the use of persons in particular situations and professions in life. Of this description is the 12th chapter on Navigation, a subject not only in itself of the very first importance to the members of the British empire, but capable, when treated at proper length, of being rendered peculiarly interesting to many other classes of readers besides that of mariners.

The principles of English grammar are stated at greater length than has usually been done in works of this sort; for this plain but powerful reason, that it is absolutely impossible, in a brief condensed shape, to put the student in possession of those principles, combined with the multiplied irregularities, defects, and redundancies, by which they are modified. These deviations from grammatical and philosophical accuracy are, in English, not only numerous, but highly important. Without entering therefore at some length into the peculiarities of the language, justice cannot be done to the reader's expectations of instruction; nor can he be duly prepared to speak and write, or even to read his mother-tongue with propriety.

On the modes and implements of writing in general, and on the uses of writing in common life, the observations are ample and practical. In conversation many improprieties of expression pass off unnoticed. In written language however, the reverse must happen, when improprieties are presented to the eye as well as to the ear, and no mistakes in grammatical arrangement, or even in common spelling, can possibly escape detection and censure. The directions for drawing up letters, memorials, &c. are the result of personal experience in public life.

The chapter on arithmetic is so comprehensive, and the grounds and reasons assigned for the methods of calculation, recommended in each branch of that essentially important subject, are stated with so much simplicity, that the student must perceive the great object has been, not to load his memory with rules for which he can discover no foundation, but to enlighten his mind, and thereby to excite him to make still greater progress in a part of education, without some portion of which, human society cannot possibly exist.

The 4th and 5th chapters contain popular explanations of two applications of arithmetic, most curious and attractive in themselves, and indispensibly necessary in many important parts of computation. By observing the several steps of an algebraic calculation, we perceive the nature and effects of many primary

operations in common arithmetic. Unless he avail himself of the admirable invention of logarithms, the practical geometrician, the surveyor of land, the geographer, the astronomer, and above all the navigator, will in his necessary computations be involved in operations so complicated and tedious, that few individuals indeed can be found sufficiently accurate, or even courageous to engage in them.

In chapter 6 the reader will find explanations and specimens of mercantile affairs and accounts, sufficiently diversified to enable him to form a system adapted to his own particular transactions. The samples of regular books are drawn from the modern practice of mercantile houses in London; and may, by a little consideration, be employed in transactions of much less extent and variety. The explanations of terms occurring in commercial language will be found peculiarly useful.

On geometry, to which the 7th division of the work is devoted, so much is stated in its proper place, as to render unnecessary any farther illustration or recommendation at present. To practical geometry, and to measurement of superficial and solid bodies, and of the work performed by tradesmen of different classes, a similar remark may be applied. Gauging it is true, and land-surveying, described and illustrated in chapters 10 and 11, are only modifications of the practice of mensuration. In their application however, matters are taken into consideration, sufficiently various and important, to entitle those branches to distinct sections in the work. The scheme of a piece of land, shown in Fig. 86, page 289, contains every variety of figure and boundary usually occurring in practical surveying: and the rules for computing its content may easily be applied in all other cases.

Of the important and interesting subject touched on in chapter 12, viz. navigation, notice has already been taken. It has been treated, as far as the limits of the work would allow, in a plain and popular way; and very imperfect as that brief sketch must be, it may excite curiosity to go deeper into the study of a branch of knowledge in which geometrical theory and mechanical practice are more powerfully and more usefully combined, than in any other application of knowledge to the benefit of human affairs.

On geography so amply explained in chap. 13, it is unnecessary to say more, than that it is formed on the best authorities, corrected by considerable personal observations of the editor himself, over the principal regions of Europe. In the present unsettled state of the continent, the reader will candidly pass over any disagreement he may discover, between the political situation of countries as described, and as existing when the book arrives at his hands. On the accuracy of the tables of latitude and longitude, of the tides, &c. full reliance may be placed. Later and more accurate observation on these subjects may nevertheless render subsequent alterations requisite.

To have entered fully and systematically on the subjects of astronomy and chronology, noticed in the 14th chapter, would have presupposed in the generality of readers an acquaintance with

various departments of geometry and natural philosophy, far more extended than ought reasonably to be expected. From what is introduced however, on those two important topics, a general but not unsatisfactory idea of them may be obtained. The chronological table of remarkable events is selected from writings of established character.

The last division of the volume is occupied in observations and illustrations of drawing or designing, including the principles of perspective, by which every part of a human figure, a building, or a landscape, is represented in its due relative position, magnitude, and colour. By attentive consideration of what is there stated, particularly with a reference to the excellent examples with which the work is embellished from the pencil of *Mr. Craig*, the student will soon be qualified to address himself to works in which drawing, in its several branches, is taught at proper length; and thus be prepared to resort to the study of the works of nature, the original and infallible instructress in the graphic art.

Such are in general the subjects treated in the present work, forming a system of instruction adapted to the circumstances and wants, and addressed to the understandings of the younger and less informed classes of the British empire. Another work of a similar construction is now however preparing for the press, for the assistance of persons of more advanced acquirements, already engaged or preparing to engage in the occupations and business of active life. Concerning the subjects to be discussed in that publication it will be sufficient at present to inform the reader that, beginning with the earliest, the most important of all the arts, *that of the husbandman*, treated at some length both in theory and practice, he will be conducted through *mechanics*, *hydrostatics*, *pneumatics*, *optics*, *electricity*, *chemistry*, *&c.* with their application in various ways to the uses of life. *Bleaching*, *dying*, *tanning*, *working in metals*, *&c.* the occupations of the *architect*, the *carpenter*, *&c.* *painting*, *engraving*, *sculpture*, *&c.* are among the articles preparing for the publication now announced. Plates will be added, exhibiting correct representations of some of the most valuable machines and instruments, employed in agriculture and natural philosophy. The appearance of this second work will be duly notified to the public, on a future occasion.

London,
May, 1815.

CONTENTS.

THE

YOUNG MAN's

BEST COMPANION.

CHAP. I.

ENGLISH LANGUAGE AND GRAMMAR.

BY language in general we are enabled to communicate one to another our ideas and feelings, either in conversation or by writing. Conversation furnishes us with information in the order and rapidity with which conceptions are formed in the mind of the speaker; and writing lays open to us the treasures of learning, science, and experience; the opinions, discoveries and transactions of the most distant ages and the most remote situations. It is in fact by language that man is chiefly distinguished from all other animals. These, indeed, have each their peculiar mode of expressing their sensations, by which they are understood among themselves: but this kind of language seems to be confined entirely to the expression of the passions; whereas in man, speech, as the organ of reason, conveys a boundless variety of expression, adapted to the various powers and faculties of the human frame. So much is this the case, that in proportion as the language of a nation is enlarged, refined, and polished, that nation is justly considered to be exalted above others, in the scale of civilization and improvement of understanding.

The student who confines his attention entirely to the study of his native tongue alone, will scarcely be able to arrive at a perfect knowledge of it, or to ascertain with precision its riches or its poverty, its beauties or its defects. He, on the other hand, who, together with his own language, cultivates those of other countries and of other times, acquires new views to increase his stock of ideas, and discovers new paths opened to him, to lead him to knowledge.

Various schemes have been formed to account for the origin of language or speech: but all, however ingenious, have failed in giving satisfaction. The only rational method of accounting for it is to refer speech, like all the other faculties of the human frame, to the

will and the operation of the great Author of our being. It is not, however, on this account necessary to suppose that the first parents of mankind were inspired with any particular set of terms, or any primitive language; but that they were made sensible of the power they possessed to form distinct articulate sounds; at the same time that, in the application of each sound to any particular object around them, they were left to the exercise of their own discretion. To their own ingenuity it was left to multiply terms and names, as new objects arose to their observation; and their language gradually advanced, in process of time, to the different degrees of accuracy, copiousness, and refinement, which it has now reached, among the various nations of the globe.

Language kept pace with the progress of invention; and the culture of the mind urged mankind to the increase and the improvement of the sounds by which its suggestions were mutually communicated to the ear. When men had formed names for the objects which presented themselves to their external senses—when they had invented sounds to denote the sun, the moon, the ground on which they stood, the tree from which they drew their food, the crystal brook which allayed their thirst—they proceeded to form expressions for the instruments and the operations of art, for the flights of fancy, for the processes and results of reasoning, for the conclusions drawn from observation and experience. In this manner may be traced the advancement of poetry, of philosophy, and of history. Thus speech, the offspring of necessity, became the parent of ornament; and words, originally the rude dress of ideas, were improved, as society advanced in refinement, into their most splendid and most beautiful decorations.

Letters or Characters expressive of Sounds.

To fix the fleeting sounds as soon as they are breathed from the lips, and to represent them faithfully to the eye, by certain determinate characters or marks—these are the wonderful properties of letters. Those to whom books have from their childhood been familiar, and who view literature only in its present improved state, are utterly unable to formed a just estimate of the difficulties which must have attended the original application of literal signs or marks to the expression of ideas in the mind.

The great excellence of letters above every other kind of representative for sounds, consists in their simplicity, and in the facility and precision with which they can be put together, so as to express every separate thought. By their aid in carrying on written correspondence, the warm effusions of affection and friendship are conveyed to the most remote corners of the world; and the constant intercourse of commerce, of science, of literature and learning is maintained, in defiance of all the obstacles of distance and intervening difficulties. Letters constitute the light, the glory, and the ornament of man; and when the voice of the poet, of the philosopher, and of the scholar, whenever the sacred words of the divine Author of our religion himself ceased to be heard, letters recorded the bright

examples of virtue, and taught the inestimable lessons of science, of learning, and of revelation, to every people and to every age.

Various have been the modes of writing adopted by various nations. Some, like the Chinese, place their letters in perpendicular rows or columns, and write from the top to the bottom of the page. Other eastern nations, as the Egyptians, the Arabians, the Phœnicians, the Hebrews, followed a different practice, and wrote from the right hand to the left. In some very ancient Greek inscriptions the lines are by turns written from the left hand to the right, and from the right to the left, the characters being reversed. This mode was called *boustrophedon,* because it resembled the progress of the ox when, in ploughing, he turns back at the end of the field, and proceeds in one furrow from left to right, and the next from right to left. The nations of Europe, however, have long taken an opposite course, and write from the left to the right. These various modes of arrangement of letters may give some plausibility to the opinion, that each people were the inventors of their own scheme of letters, or of their own alphabet. Our European alphabets, however, may be traced back successively to the Romans, the Greeks, the Phœnicians, &c.

English Language.

The effects produced by conquerors who settle in any particular country are in few respects more perceptible than in the change introduced by the conquest into the language of the original inhabitants. This observation is fully confirmed by the history of England: for the Saxons, after they had subdued the native Britons, introduced into the country their own language, which was a dialect of the ancient Teutonic, the parent of the present languages of Germany and the Low Countries.

No alteration in the language of England occurred, after this event, for six hundred years, until the conquest in 1066 by William of Normandy, who promoted another change, by causing Norman French to be used, even in the courts of justice. The original British tongue, the Saxon, and the old French, are therefore the sources of the modern English; but augmented, from time to time, by the influx of Latin and Greek terms, with which commerce, the cultivation of learning, and the progress of the arts, have made us familiar.

From the countries which have supplied us with improvements in knowledge and art, we have also drawn the terms belonging to them. Thus in music, sculpture, and painting, the terms are borrowed from Italy, where these arts have been carried to the highest perfection. The names and phrases employed in navigation were received from the inhabitants of Flanders and Holland. France has supplied us with the language of fortification and military affairs, which she herself originally borrowed from Italy. The language of mathematics and philosophy is formed upon the Greek and Latin. The Saxon, and a few remains of the original British or Celtic, furnish most of the words in common use, as

well as those employed in agriculture and in several mechanic arts.

The English language is now spoken or understood over a greater extent of the world than any other. Besides the British isles in Europe, it is the common tongue of the whole of the civilized parts of the United States of North America, besides many parts of Canada, and the British American islands. In Asia, English is the speech of the masters of India, ruling over a prodigious population exceeding fifty millions. In the newly formed settlements in the great Southern Ocean, in New Holland, &c. it is the only language in use. With French and German, however, a traveller will more commodiously make his way over the continent of Europe.

Grammar in general.

Grammar is the art of properly expressing our thoughts by words. The term is originally Greek, signifying a mark, character, or letter, written or engraved, to represent certain ideas or perceptions. Hence arises the impropriety of employing the term in any other sense, as in the expressions and titles of certain modern books, called Grammars of History, of Geography, of Chemistry, and the like.

Grammar in general, or, as it is usually styled, Universal Grammar, explains the principles which regulate, and are consequently common to all languages. Being founded on reason and the nature of things, these principles and the grammátical rules resulting from them, are susceptible of no variation, from any change of time or of place.

The grammar of the English, or any other particular tongue, applies these principles to that tongue, according to the custom and usage established in it, by the best practice.

Grammar treats of sentences, and of the several parts of which sentences are composed. Sentences consist of words: words are formed by one or more syllables; syllables contain one letter or several letters. Hence letters, syllables, words, and sentences, make up the whole of the grammar of any language.

Letters.

A letter or character is the expression of any simple sound or modification of sound, or of the articulate utterance of the human voice, regulated by the organs of speech.

Sounds, and consequently letters, are naturally divided into two classes; the one produced by a simple emission of the voice, as *a, o,* which may be lengthened or continued at pleasure. This class proceeding only from the voice, is therefore from the Latin term for voice called vowels. The other class of letters representing certain restraints or modifications of simple sounds, can be pronounced only by the help of some vowel before or after them, and are therefore called consonants, from two Latin words signifying to sound together. Thus the letter *b* represents in fact only

a suppression of all sound, and can be pronounced only by the means of a vowel before or after it, as *ab*, or *be*.

When the vowels are brought together, so that each is sounded so quickly that the two together seem to form but one sound, composed of the two in succession: or that out of the two is formed a third sound different from both, these combinations of vowels are termed diphthongs, from two Greek words, signifying a double sound. Thus in English, *ou* in the word *bound* is a diphthong in which both *o* and *u* are separately but rapidly pronounced; whereas in the word *food* the two vowels *o, o,* represent a sound totally different from their own proper sound.

The letters or characters used to represent the most common simple sounds of a language compose its alphabet, a term consisting of the names of the first two letters in the Greek language, called *alpha* and *beta*, that is *a* and *b*. Had languages originally been constructed, and letters invented, upon certain fixed principles, every separate sound would have been expressed by a separate letter, or by the combination of two or more letters of invariable pronunciation. On the other hand, every separate letter or combination of letters would have been restricted to the expression of one particular sound, to the exclusion of all others. This, however, was not the case in the formation of any language or alphabet: and the consequence is, that in all we find one letter expressing various sounds, and one sound expressed by various letters. The English alphabet is therefore both redundant and deficient.

In the English alphabet are twenty-six letters, in the following order:

A a, B b, C c, D d, E e, F f, G g, H h, I i, J j, K k, L l, M m, N n, O o, P p, Q q, R r, S s, T t, U u, V v, W w, X x, Y y, Z z.

Of these, six are vowels, A, E, I, O, U, Y: the others are consonants.

SYLLABLES.

A syllable is one sound, either that of a simple vowel, as *a* in the word *abound*, or that of a combination of vowels and consonants, as *bound* in the same word. Syllable is a Greek term, signifying what things may be taken together.

Spelling is the art of reading, by naming the letters separately, putting them together, and rightly dividing words into their proper syllables. In writing, to spell is to express a word by its proper letters.

The mode of spelling words is termed *orthography*, a Greek expression equivalent to right writing. Not only in modern, but also in ancient languages, we find various modes of spelling in use; and at times without any appearance of rule or established practice. In some old English writers the same word occurs differently spelt even in the same page. Various attempts have been made by learned men, at different times, to ascertain and fix the orthography of the English language: but their success, however

rationally founded, has not been sufficient to establish beyond alteration any one mode of spelling. In orthography as in several other practices, founded perhaps as much upon caprice and fashion as upon reason, we must follow the old advice—

> Be not the first by whom the new are tried;
> Nor yet the last to lay the old aside.

In dividing words into syllables the following directions are commonly given: A consonant coming between two vowels is to be joined to the last vowel, as in *a-rise, i-mage.* When two consonants are placed between two vowels, the first consonant is joined to the first vowel, and the last to the vowel following, as in *ab-sent, ad-dress.* But if the two consonants be such as easily to unite in pronunciation, particularly if they be found to begin a word, they are not to be separated, but to go with the last vowel, in the same way with a single consonant. Thus in the name *A-drian* the *d* and *r* go together to the last vowel *i*, because *dr* unite with ease in sound; and many words begin with those consonants, as *draw, drown.* In the same way when three consonants meet in the middle of a word, the first is generally joined to the foregoing vowel, and the two remaining consonants go to the following vowel, as in *as-tray, as-tronomy.* But as these three consonants are often found to begin a word, as in *strange, strength,* some grammarians would divide the former words thus, *a-stray, a-stronomy.* These general directions are, however, subject to so many exceptions, that the only method of attaining a proper mode of dividing words into syllables is carefully to observe and to imitate the practice of the best writers, and the examples laid before us in the most accurately printed books.

Grammar consists of four principal parts—Orthography, Etymology, Syntax, and Prosody.

1. *Orthography* is a Greek term, signifying strictly the art of rightly expressing words in writing; but under the same term is comprehended the sister art of reading and pronouncing with propriety. It is therefore the method of combining letters into syllables, and syllables into words.

2. *Etymology* is that part of grammar which teaches the formation and derivation of one word from another, and the various methods by which the sense of any word may be changed, to suit the circumstances in which it is employed.

3. *Syntax,* or, as it is often called, *Construction,* is the proper order and arrangement of words in a sentence, so as to make the meaning perfectly clear and distinct.

Syntax is subdivided into *Concord* and *Regimen. Concord* signifies the agreement in all circumstances, between two terms belonging to and expressive of one and the same object or idea. *Regimen,* or government, signifies the power which one word is supposed to possess of causing some other word, on which it acts, to be in certain fixed circumstances, according to the case.

4. *Prosody* is a part of grammar employed in determining the true pronunciation of words, and the rules and practices of versification and poetry.

Of these four component parts of grammar, the first, or orthography, and the last, or prosody, particularly in the English, and most other living languages, are liable to frequent and even capricious fluctuations, and consequently far less susceptible of fixed and determinate rules in practice than the other parts, etymology and syntax. The former parts can best be learned from the writings of the most approved authors in prose and verse: the latter two parts, being governed by established regulations, require more particular consideration and illustration.

Etymology.

The words of all languages may be arranged in different classes, according to their signification, as representing ideas or perceptions, and their connection the one with the other.

On the revival of literature and science in the 15th century, the Latin tongue, in which many important and excellent works had come down from antiquity, being also the common language of the Roman church, then established over the greatest part of Europe, it was naturally adopted as the common vehicle of intercourse and information among men of learning. Hence all works relative to the study, not of the Latin only, but of the Greek, the Hebrew, and other ancient tongues, were composed in Latin: and by a very obvious transition, the terms formed from that language were employed in works relating only to modern tongues. This was particularly the case in grammatical treatises, on the languages of the southern states of Europe, in Italy, France, Spain and Portugal, and even in Britain, notwithstanding the close connection between the English language and those of Germany and the northern states of Europe, where a different system of grammatical expressions is adopted.

There are in English nine sorts of words, or, as they are commonly called, parts of speech.

1. The Article; prefixed to substantives, when they are common names of things, to point them out, and to show how far their signification extends.

2. The Substantive, or Noun; being the name of any thing conceived to subsist, or of which we have any notion.

3. The Pronoun; standing instead of the noun.

4. The Adjective; added to the noun to express the quality of it.

5. The Verb, or word, by way of eminence; signifying to be, to do, or to suffer.

6. The Adverb; added to verbs, and also to adjectives and other adverbs, to express some circumstance belonging to them.

7. The Preposition; put before nouns and pronouns chiefly, to connect them with other words, and to show their relation to those words.

8. The Conjunction; connecting sentences together.

9. The Interjection; thrown in to express the affection of the speaker, though unnecessary with respect to the construction of the sentence.

EXAMPLE.

The[1] power[2] of[7] speech[2] is[5] a[1] faculty[2] peculiar[4] to[7] man[2], and[8] was[5] bestowed[5] on[7] him[3] by[7] his[3] beneficent[4] Creator[2] for[7] the[1] greatest[4] and[8] most[6] excellent[4] uses[2]; but[8] alas[9]! how[6] often[6] do[5] we[3] pervert[5] it[3] to[7] the[1] worst[4] of[7] purposes[2].

In the foregoing sentence, the words, *the, a,* are articles; *power, speech, faculty, man, Creator, uses, purposes,* are substantives; *him, his, we, it,* are pronouns; *peculiar, beneficent, greatest, excellent, worst,* are adjectives; *is, was, bestowed, do, pervert,* are verbs; *most, how, often,* are adverbs; *of, to, on, by, for,* are prepositions; *and, but,* are conjunctions; and *alas* is an interjection.

The substantives, *power, speech, faculty,* and the rest, are general, or common, names of things; whereof there are may sorts belonging to the same kind; or many individuals belonging to the same sort: as there are many sorts of power, many sorts of speech, many sorts of faculty, many individuals of that sort of animal called man; and so on. These general or common names are here applied in a more or less extensive signification: according as they are used without either, or with the one, or with the other, of the two articles *a* and *the*. The words *speech, man,* being accompanied with no article, are taken in their largest extent; and signify all of the kind or sort; all sorts of speech and all men. The word *faculty,* with the article *a* before it, is used in a more confined signification, for some one out of many of that kind: for it is here implied, that there are other faculties peculiar to man beside speech. The words *power, Creator, uses, purposes,* with the article, *the* before them (for *his* Creator is the same as *the* Creator *of him*), are used in the most confined signification, for the things here mentioned and ascertained: *the power* is not any one indeterminate power out of many sorts, but that particular sort of power here specified; namely, the power of speech: *the Creator* is the one great Creator of man and of all things: *the uses,* and *the purposes,* are particular uses and purposes; the former are explained to be those in particular, that are the greatest and most excellent; such, for instance, as the glory of God, and the common benefit of mankind; the latter to be the worst, as lying, slandering, blaspheming, and the like.

The pronouns, *him, his, we, it,* stand instead of some of the nouns, or substantives, going before them; as *him* supplies the place of *man; his* of *man's; we,* of *men,* implied in the general name *man,* including all men (of which number is the speaker;) *it,* of *the power* before mentioned. If, instead of these pronouns, the nouns for which they stand had been used, the sense would have been the same; but the frequent repetition of the same words would have been disagreeable and tedious: as the power of speech peculiar to *man,* bestowed on *man,* by *man's* Creator, &c.

The adjectives, *peculiar, beneficent, greatest, excellent, worst,* are added to their several substantives, to denote the character and quality of each.

The verbs, *is, was bestowed, do pervert,* signify severally, being, suffering, and doing. By the first it is implied, that there is such a thing as the power of speech, and it is affirmed to be of such a kind; namely, a faculty peculiar to man: by the second it is said to have been acted upon, or to have had something done to it; namely, to have been bestowed on man: by the last we are said to act upon it, or to do something to it; namely, to pervert it.

The adverbs, *most, often,* are added to the adjective *excellent,* and to the verb *pervert,* to shew the circumstance belonging to them; namely, that of the highest degree to the former, and that of frequency to the latter; concerning the degree of which frequency also a question is made by the adverb *how* added to the adverb *often.*

The prepositions *of, to, on, by, for,* placed before the substantives and pronouns, *speech, man, him,* &c. connect them with other words, substantives, adjectives, and verbs; as, *power, peculiar, bestowed,* &c. and shew the relation which they have to those words; as the relation of subject, object, agent, end; *for* denoting the end; *by* the agent, *on* the object; *to* and *of* denote possession, or the belonging of one thing to another.

The conjunctions, *and,* and *but,* connect the three parts of the sentence together; the first more closely, both with regard to the sentence and the sense; the second connecting the parts of the sentence, though less strictly, and at the same time, expressing an opposition in the sense.

The interjection, *alas!* expresses the concern and regret of the speaker; and though thrown in with propriety, yet might have been omitted, without injuring the construction of the sentence, or destroying the sense.

ARTICLE.

The Article is a word prefixed to substantives, to point them out and to shew how far their signification exends.

In English there are but two articles, *a,* and *the:* *a* becomes *an* before a vowel, *y* and *w* excepted; and before a silent *h* preceding a vowel.

A is used in a vague sense to point out one single thing of the kind, in other respects indeterminate: *the* determines what particular thing is meant.

A substantive, without any article to limit it, is taken in its widest sense: thus *man* means all mankind; as,

"The proper study of mankind is man."

Pope.

Where *mankind* and *man* may change places, without making any alteration in the sense. *A man* means some one or other of that kind, indefinitely; *the man* means, definitely, that particular man,

spoken of, may be many; so each of these persons hath the plural number; *we, ye, they.*

The person speaking and spoken to, being at the same time the subjects of the discourse, are supposed to be present; from which and other circumstances their sex is commonly known, and needs not be marked by a distinction of gender in their pronouns: but the third person or thing spoken of being absent, and in many respects unknown, it is necessary, that it should be marked by a distinction of gender; at least when some particular person or thing is spoken of which ought to be more distinctly marked: accordingly the pronoun singular of the third person hath the three genders: *he, she, it.*

Pronouns have three cases; the nominative, the genitive or possessive, like nouns; and moreover a case, which follows the verb active, or the preposition, expressing the object of an action, or of a relation. It answers to the oblique cases in Latin, and may be properly enough called the Objective case.

Pronouns;

according to their persons, numbers, cases, and genders.

PERSONS.

Singular.			Plural.		
1.	2.	3.	1.	2.	3.
I,	Thou,	He;	We,	Ye or You,	They.

CASES.

Nom.	Poss.	Obj.	Nom.	Poss.	Obj.
		First Person.			
I.	Mine,	Me;	We,	Ours,	Us.
		Second Person.			
Thou,	Thine,	Thee;	Ye or You,	Yours,	You.
		Third Person.			
Mas. He,	His,	Him;	They,	Theirs,	Them.
Fem. She,	Hers,	Her;			
Neut. It,	Its,	It;			

The personal pronouns have the nature of substantives, and, as such, stand by themselves; the rest have the nature of adjectives, and, as such, are joined to substantives; and may be called pronominal adjectives.

Thy, my, her, ours, yours, their, are pronominal adjectives: but *his* (that is, *he's*), *her's, our's, your's, their's,* have evidently the form of the possessive case: and by analogy, *mine, thine,* may be esteemed of the same rank. All these are used, when the Noun, to which they belong, is understood; the two latter sometimes also instead of *my, thy,* when the noun following them begins with a vowel.

Besides the foregoing, there are several other pronominal adjec-

tives; which, though they may sometimes seem to stand by themselves, yet have always some substantive belonging to them, either referred to or understood: as *this, that, other, any, some, one, none.* These are called definitive, because they *define* and limit the extent of the common name, or general term, to which they refer, or are joined. The three first of these are varied, to express number; as, *these, those, others;* the last of which admits of the plural form only when its substantive is not joined to it, but referred to, or understood; none of them are varied to express the gender: only two of them to express the case; as, *other, one,* which have the possessive case. *One* is sometimes used in an indefinite sense (answering to the French *on*), as in the following phrases: "*one* is apt to think;" "*one* sees;" "*one* supposes." *Who, which, that,* are called relatives, because they more directly *refer* to some substantive, *going before,* which therefore is called the antecedent. They also connect the following part of the sentence with the foregoing. These belong to all the three persons; whereas the rest belong only to the third. One of them only is varied to express the three cases; *Who, whose* (that is, *who's*), *whom:* none of them have different endings for the numbers. *Who, which, what,* are called interrogatives, when they are used in *asking questions.* The two latter of them have no variation of number or case. *Each, every, either,* are called distributive; because they denote the persons, or things, that make up a number, as taken *separately* and singly.

ADJECTIVE.

An Adjective is a word *added to* a substantive to express its quality.

In English the adjective is not varied on account of gender, number, or case. The only variation which it admits of, is that of the degrees of comparison.

Qualities, for the most part, admit of *more* and *less,* or of different degrees, and the words that express such qualities have accordingly proper forms to express different degrees. When a quality is simply expressed without any relation to the same in a different degree, it is called the Positive; as, *wise, great.* When it is expressed with augmentation, or with reference to a less degree of the same, it is called the Comparative; as, *wiser, greater;* when it is expressed as being in the highest degree of all, it is called the Superlative; as, *wisest, greatest.*

So that the simple word, or positive, becomes comparative by adding *r,* or *er:* and superlative by adding *st,* or *est,* to the end of it. And the adverbs *more* and *most* placed before the adjective have the same effect; as, *wise, more wise, most wise.*

Monosyllables, for the most part, are compared by *er* and *est:* and disyllables by *more* and *most:* as *mild, milder, mildest: frugal, more frugal, most frugal.* Dissyllables ending in *y, happy, lovely;* and in *le* after a mute, as *able, ample;* or accented on the last

syllable, as, *discreet, polite;* easily admit of *er* and *est.* Words of more than two syllables hardly ever admit of those terminations.

In some few words the superlative is formed by adding the adverb *most* to the end of them; as, *nethermost, uttermost,* or *utmost, undermost, uppermost, foremost.*

In English, as in most languages, there are some words of very common use (in which the caprice of custom is apt to get the better of analogy), that are irregular in this respect: as, *good, better, best; bad, worse, worst; little, less, least; much,* or *many, more, most;* and a few others. *Lesser* is only a corruption of *less.*

Verb.

A Verb is a *word* which signifies to be, to do, or to suffer.

There are three kinds of verbs; Active, Passive, and Neuter verbs.

A Verb Active expresses an action, and necessarily implies an agent, and an object acted upon; as, *to love;* "I love Thomas."

A Verb Passive expresses a passion, or a suffering, or the receiving of an action; and necessarily implies an object acted upon, and an agent by which it is acted upon; as, *to be loved;* "Thomas is loved by me."

A Verb Neuter expresses being; or a state or condition of being; when the agent and the object acted upon coincide, and the event is properly neither action nor passion, but rather something between both; as, *I am, I sleep, I walk.*

The verb active is called also Transitive; because the action *passeth over* to the object, or hath an effect upon some other thing; and the verb neuter is called Intransitive; because the effect is confined within the agent, and doth *not pass over* to any object.

In English many verbs are used both in an active and neuter signification, the construction only determining of which kind they are.

To the signification of the verb is superadded the designation of person, by which it corresponds with the several personal pronouns; of number, by which it corresponds with the number of the noun, singular or plural; of time, by which it represents the being, action, or passion, as present, past, or future, whether imperfectly, or perfectly; that is, whether passing in such time, or then finished; and lastly of mode, or of the various manners in which the being, action, or passion is expressed.

In a verb, therefore, are to be considered the person, the number, the time, and the mode.

The verb in some parts of it varies its endings, to express, or agree with, different persons of the same number; as, "I *love,* Thou *lovest,* He *loveth,* or *loves.*"

So also to express different numbers of the same person: as, "Thou *lovest,* Ye *love:* He *loveth,* They *love.*"

So likewise to express different times in which any thing is

represented as being, acting, or acted upon: as, "I *love*, I *loved*: I *bear*, I *bore*, I have *borne*."

The Mode is the *manner* of representing the being, action, or passion. When it is simply *declared*, or a question asked, in order to obtain a *declaration* concerning it, it is called the Indicative mode; as, "I *love*: *lovest* thou?" when it is *bidden*, it is called the Imperative; as, "*love* thou;" when it is *subjoined* as the end or design, or mentioned under a condition, a supposition, or the like, for the most part depending on some other verb, and having a conjunction before it, it is called the Subjunctive; as, "If I *love*: if thou *love*:" when it is barely expressed *without any limitation* of person or number, it is called the Infinitive; as, "*to love*:" and when it is expressed in a form in which it may be joined to a noun as its quality or accident, *partaking* thereby the nature of an adjective, it is called the participle; as, "*loving*."

But to express the time of the verb, the English uses also the assistance of other verbs, called therefore auxiliaries, or helpers; *do, be, have, shall, will*: as, "I *do* love, I *did* love; I *am* loved, I *was* loved; I *have* loved, I *have been* loved; I *shall* or *will* love, or *be* loved."

The two principal auxiliaries, *to have*, and *to be*, are thus varied, according to person, number, time, and mode.

Time is Present, Past, or Future.

TO HAVE.

Indicative Mode.

Present Time.

Person.		
1.	I have,	We have
2.	Thou hast,*	Ye have
3.	He hath, or has;	They have

Past Time.

1.	I had,	We had.
2.	Thou hadst,	Ye had.
3.	He had;	They had.

Future Time.

1.	I shall, or will, have;	We shall, or will, have.
2.	Thou shalt, or wilt, have;	Ye shall, or will, have.
3.	He shall, or will, have;	They shall, or will, have.

Imperative Mode.

1.	Let me have,	Let us have,
2.	Have thou, or, Do thou have,	Have ye, or, Do ye have
3.	Let him have;	Let them have.

* *Thou*, in the polite, and even in the familiar style, is disused, and the plural *you* is employed instead of it; we say, *you have*; not *thou hast*. Though in this case we apply *you* to a single person, yet the verb too must agree with it in the plural number: it must necessarily be *you have*; not *you hast*. *You was*, the second person plural of the pronoun, placed in agreement with the first or third person singular of the verb, is an enormous solecism: and yet authors of the first rank have inadvertently fallen into it. "Knowing that *you was* my old master's good friend." Addison, Spect. No. 517. "The account *you was* pleased to send me." Bently, Phileleuth. Lips. part II. See the Letter prefixed. "Would to God *you was* within her reach!" Bolingbroke to Swift, Letter 46. "If *you was* here." Ditto, Letter 47. "I am just now as well as when *you was* here." Pope to Swift, P. S. to Letter 56. On the contrary, the solemn style admits not of *you* for a single person.

Subjunctive Mode.

Present Time.

1. I, 2. Thou, 3. He — have;	We, Ye, They — have.

Infinitive Mode.

Present, To have: Past, To have had

Participle.

Present, Having: Perfect, Had:
Past, Having had.

TO BE.

Indicative Mode.

Present Time.

1. I am,	We
2. Thou art,	Ye — are.
3. He is;	They

Or,

1. I be,	We
2. Thou beest,	Ye — be.
3. He is;	They

Past Time.

1. I was,	We
2. Thou wast,	Ye — were.
3. He was;	They

Future Time.

1. I shall, or will,	We
2. Thou shalt, or wilt, — be;	Ye — shall, or will, be.
3. He shall, or will,	They

Imperative Mode.

1. Let me be,	Let us be,
2. Be thou,	Be ye,
or, Do thou be,	or, Do ye be,
3. Let him be;	Let them be;

Subjunctive Mode.

1. I, 2. Thou, 3. He — be;	We, Ye, They — be.

Past Time.

1. I were,	We
2. Thou wert,	Ye — were.
3. He were;	They

Infinitive Mode.

Present, To be: Past, To have been.

Participle.

Present, Being: Perfect, Been.
Past, Having been.

The Verb Active is thus varied according to Person Number, Time, and Mode:—

Indicative Mode.

Present Time.

	Sing.	*Plural.*
Person	1. I love,	We love.
	2. Thou lovest,	Ye love.
	3. He loveth, or loves,	They love.

Past Time.

1. I loved,	We loved.
2. Thou lovedst,	Ye loved.
3. He loved;	They loved.

Future Time.

1. I shall, or will, love;	We shall, or will, love.
2. Thou shalt, or wilt, love;	Ye shall, or will, love.
3. He shall, or will, love;	They shall, or will, love.

Imperative Mode.

1. Let me love,	Let us love,
2. Love thou, or, Do thou love,	Love ye, or, Do ye love,
3. Let him love;	Let them love.

Subjunctive Mode.

Present Time.

1. I love;	We love.
2. Thou love;	Ye love.
3. He love;	They love.

And,

1. I may love;	We may love, and have loved.
2. Thou mayest love;	Ye may love, and have loved.
3. He may love;	They may love, and have loved.

Past Time.

1. I might love;	We might love, and have loved.
2. Thou mightest, love;	Ye might love, and have loved.
3. He might love;	They might love, and have loved.

And,

I could, should, would; Thou couldest, &c. love: and have loved.

Infinitive Mode.

Present, To love: Past, To have loved.

Participle.

Present, Loving: Perfect, Loved:
Past, Having loved.

But in discourse we have often occasion to speak of time, not only as present, past, and future, at large and indeterminately; but also as such with some particular distinction and limitation; that is, as passing, or finished; as imperfect or perfect. This will be best seen in an example of a verb laid out and distributed according to these distinctions of time.

Indefinite, or Undetermined Time.

Present, I love; Past, I loved; Future, I shall love.

Definite, or Determined Time.

Present Imperfect: I am (now) loving.

Present Perfect:	I have (now) loved.
Past Imperfect:	I was (then) loving.
Past Perfect:	I had (then) loved.
Future Imperfect:	I shall (then) be loving.
Future Perfect:	I shall (then) have loved

To express the present and past imperfect of the active and neuter verb, the auxiliary *do* is sometimes used: I *do* (now) love, I *did* (then) love.

Thus, with very little variation of the principal verb, the several circumstances of mode and time are clearly expressed, by the help of the auxiliaries, *be, have, do, let, may, be, can, shall, will.*

Let does not only express permission; but praying, exhorting, commanding. *May* and *might* express the possibility or liberty of doing a thing; *can* and *could*, the power. *Must* is sometimes called in for a helper, and denotes necessity. *Will*, in the first person singular and plural, promises or threatens; in the second and third person, only foretels; *shall*, on the contrary, in the first person, simply foretels; in the second and third persons, promises, commands, or threatens. But this must be understood of explicative sentences; for when the sentence is interrogative, just the reverse, for the most part, takes place: Thus, "I *shall* go; you *will* go;" express event only: but, "*will* you go?" imports intention; and "*shall* I go?" refers to the will of another. But again, "he *shall* go" and "*shall* he go?" both imply will, expressing or referring to a command. *Would* primarily denotes inclination of will; and *should*, obligation: but they both vary their import, and are often used to express simple event.

Do and *have* make the present time; *did, had,* the past; *shall, will,* the future; *let* is employed in forming the imperative mode; *may, might, could, would, should,* in forming the subjunctive. The preposition *to*, placed before the verb, makes the infinitive mode. *Have*, through its several modes and times, is placed only before the perfect participle; and *be* in like manner, before the present and passive participles; the rest only before the verb, or another auxiliary, in its primary form.

When an auxiliary is joined to the verb, the auxiliary goes through all the variations of person and number; and the verb itself continues invariably the same. When there are two or more auxiliaries joined to the verb, the first of them only is varied according to person and number. The auxiliary *must* admits of no variation.

The passive verb is only the participle passive (which for the most part is the same with the indefinite past time, active, and always the same with the perfect participle), joined to the auxiliary verb *to be*, through all its variations: as, "I *am loved*: I *was loved*: I *have been loved*: I *shall be loved*:" and so on, through all the persons, the numbers, the times, and the modes.

The neuter verb is varied like the active; but having somewhat of the nature of the passive, admits in many instances of the passive form, retaining still the neuter signification; chiefly in such verbs, as signify some sort of motion, or change of place or condition: as,

"I *am come*: I *was gone*: I *am grown*: I *was fallen*." The verb *am*, *was*, in this case precisely defines the time of the action or event, but does not change the nature of it; the passive form still expressing, not properly a passion, but only a state or condition of being.

Irregular Verbs.

In English, both the past time active and the participle perfect, or passive, are formed by adding to the verb *ed*; or, *d* only, when the verb ends in *e*; as, "*turn, turned: love, loved*." The verbs that vary from this rule, in either or in both cases, are esteemed irregular.

Verbs ending in *ch, ck, p, x, ll, ss*, in the past time active, and the participle perfect or passive, admit the change of *ed* into *t*; as, *snatcht, checkt, snapt, mixt*, dropping also one of the double letters, *dwelt, past*: for *snatched, checked, snapped, mixed, dwelled, passed*: those that end in *l, m, n, p*, after a diphthong, moreover shorten the diphthong, or change it into a single short vowel; as *dealt, dreamt, meant, felt, slept*, &c. all for the same reason; from the quickness of the pronunciation, and because the *d* after a short vowel will not easily coalesce with the preceding consonant. Those that end in *ve* change also *ve* into *f*; as, *bereave, bereft, leave, left*: because likewise *v* after a short vowel will not easily coalesce with *t*.

I.

Irregulars by Contraction.

Some verbs ending in *d* or *t* have the present, the past time, and the participle perfect and passive, all alike without any variation; as, beat, burst, cast, cost, cut, heat, hit, hurt, knit, let, lift, light, put, quit, read, rent, rid, set, shed, shred, shut, slit, split, spread, thrust, wet.

These are contractions from *beated, bursted, casted*, &c.; because of the disagreeable sound of the syllable *ed* after *d* or *t*.

Others in the past time, and participle perfect and passive, vary a little from the present, by shortening the diphthong, or changing the *d* into *t*; as, lead, led; sweat, swet; meet, met; bleed, bled, breed, bred; feed, fed; speed, sped; bend, bent; lend, lent; rend, rent; send, sent; spend, spent; build, built (1); geld, gelt; gild, gilt; gird, girt; lose, lost.

Others not ending in *d* or *t* are formed by contraction; have, *had*, for *haved*; make, *made*, for *maked*; flee, *fled*, for *flee-ed*; shoe, *shod*, for *shoe-ed*.

The following, beside the contraction, change also the vowel; sell, sold; tell, told; clothe, clad (1).

Stand, stood; and dare, durst (which in the participle hath regularly *dared*), are directly from the Saxon, *standan, stod; dyrran, dorste*.

II.

Irregulars in *ght.*

The Irregulars of the second class end in *ght,* both in the past time and participle; and change the vowel or diphthong into *au* or *ou:* they are taken from the Saxon, in which the termination is *hte.*

		Saxon.	
Bring,	brought:	Bringan,	brohte.
Buy,	bought:	Bycgean,	bohte.
Catch,	caught.		
Fight,	fought:	Feotan,	fuht.
Teach,	taught:	Tæchan,	tæhte.
Think,	thought:	Thencan,	thohte.
Seek,	sought:	Secan,	sohte.
Work,	wrought:	Woercan,	worhte.

Fraught seems rather to be an adjective than the participle of the verb to *freight,* which has regularly *freighted. Raught* from *reach* is obsolete.

III.

Irregulars in *en.*

The Irregulars of the third class form the past time by changing the vowel or diphthong of the present; and the participle perfect and passive, by adding the termination *en;* beside, for the most part, the change of the vowel or diphthong. These also derive their formation in both parts from the Saxon.

Present.		Past.	Participle.
a changed into		*e*	
Fall,		fell,	fallen.
a	into	*o*	
Awake,		awoke,	[awaked.]
a	into	*oo.*	
Forsake,		forsook,	forsaken.
Shake,		shook,	shaken.
Take,		took,	taken.
aw	into	*ew.*	
Draw,		drew,	drawn.
ay	into	*ew.*	
Slay,		slew,	slain.
e	into	*a* or *o,*	*o.*
Get,		gat, or got,	gotten.
Help,		[helped,]	holpen.
Melt,		[melted,]	molten.
Swell,		[swelled,]	swollen.
ea	into	*a* or *o.*	
Eat,		ate,	eaten.

			o.
Bear,	bare,	or bore,	born.
Break,*	brake,	or broke,	broken.
Cleave,	clave,	or clove,	cloven, or cleft.
Speak,	spake,	or spoke,	spoken.
Swear,	sware,	or swore,	sworn.
Tear,	tare,	or tore,	torn.
Wear,	ware,	or wore,	worn.
Heave,	hove,		hoven.
Shear,	shore,		shorn.
Steal,	stole,		stolen, or stoln.
Tread,	trode,		trodden.
Weave,	wove,		woven.
ee into	*o,*		*o.*
Creep,	crope,		[creeped, or crept.]
Freeze,	froze,		frozen.
Seethe,	sod,		sodden.
ee into	*aw*		
See,	saw,		seen.
i long into	*i* short,		*i* short.
Bite,	bit,		bitten.
Chide,	chid,		chidden.
Hide,	hid,		hidden.
Slide,	slid,		slidden.
i long into	*o,*		*i* short.
Abide,	abode.		
Climb,	clomb,		[climbed.]
Drive,	drove,		driven.
Ride,	rode,		ridden.
Rise,	rose,		risen.
Shine,	shone,		[shined.]
Shrive,	shrove,		shriven.
Smite,	smote,		smitten.
Stride,	strode,		stridden.
Strive,	strove,		striven.
Thrive,	throve,		thriven.
Write,	wrote,	or writ,	written.
i long into	*u,*		*i* short.
Strike,	struck,		stricken, or strucken.
i short into	*a.*		
Bid,	bade,		bidden.
Give,	gave,		given.
Sit,	sat,		sitten.
Spit,	spat,		spitten.
i short into	*u.*		
Dig,	dug,		[digged.]
ie into	*ay.*		
Lie,*	lay,		lien, or lain.

* This neuter verb is frequently confounded with the verb active *to lay,* [that is to *put* or place;] which is regular, and has in the past time and participle *layed* or *laid.*

o into	*e.*	
Hold,	held,	holden.
o into	*i.*	
Do,	did,	done, i. e. doen.
oo into	*o.*	
Choose,	chose,	chosen.
ow into	*ew.*	
Blow,	blew,	blown.
Crow,	crew,	[crowed.]
Grew,	grew,	grown.
Know,	knew,	known.
Throw,	threw,	thrown.
y into	*ew,*	*ow.*
Fly,*	flew,	flown.†

The following are irregular only in the participle; and that without changing the vowel.

Bake,	[baked,]	baken.
Fold,	[folded,]	folden.
Grave,	[graved,]	graven.
Hew,	[hewed,]	hewen, or hewn.
Lade,	[laded,]	laden.
Load,	[loaded,]	loaden.
Mow,	[mowed,]	mown.
Owe,	[owed, or ought,]	owen.
Rive,	[rived,]	riven.
Saw,	[sawed,]	sawn.
Shape,	[shaped,]	shapen.
Shave,	[shaved,]	shaven.
Shew, or	[shewed,]	shewn.
Show,	[showed,]	shown.
Sow,	[sowed,]	sown.
Straw, -ew, or -ow,	[strawed, &c.]	strown.
Wash,	[washed,]	washen.
Wax,	[waxed,]	waxen.

"For him, through hostile camps I bent my way;
For him, thus prostrate at thy feet I *lay*:
Large gifts proportioned to thy wrath I bear."

Pope, Iliad, xxiv. 622.

Here *lay* is evidently used for the present time, instead of *lie*. "Before they *were laid* down." Josh. ii. 8. "And he *was laid* down." 2 Sam xiii. 8. It ought to be, *had lien*, or *lain* down. See also Rut iii. 7. 1 Sam iii. 2, 3. 1 Kings xix. 6. xxi. 4.

* That is, as a bird in Latin, *volare*; whereas *to flee* signifies *fugere*, as from an enemy. This seems to be the proper distinction between *to fly*, and *to flee*; which in the present times are very often confounded. Our translation of the Bible is not quite free from this mistake. It hath *flee* for *volare*, in perhaps seven or eight places out of a great number; but never *fly* for *fugere*.

† "For rhyme in Greece or Rome was never known,
Till by barbarian deluges *o'erflown*."

Roscommon, Essay.

"Do not the Nile and the Niger make yearly inundations in our days, as they have formerly done? and are not the countries so *overflown* still situate between the tropics?"—Bentley's Sermons.

"Thus oft by mariners are shown.
Earl Godwin's castles *overflown*."—Swift.

Here the participle of the irregular verb, *to fly*, is confounded with that of the regular verb, *to flow*. It ought to be in all these places *overflowed*.

Wreath,	[wreathed,]	wreathen.
Writhe,	[writhed,]	writhen.

Some verbs, which change *i* short into *a* or *u*, and *i* long into *ou*, have dropped the termination *en* in the participle.

i short into	*a* or *u*,	*u*.
Begin,	began,	begun.
Cling,	clang, or clung,	clung.
Drink,	drank,	drunk, or drunken.
Fling,	flung,	flung.
Ring,	rang, or rung,	rung.
Shrink,	shrank, or shrunk,	shrunk.
Sing,	sang, or sung,	sung.
Sink,	sank, or sunk,	sunk.
Sling,	slang, or slung,	slung.
Slink,	slunk,	slunk.
Spin,	span, or spun,	spun.
Spring,	sprang, or sprung,	sprung.
Sting,	stung,	stung.
Stink,	stank, or stunk,	stunk,
String,	strung,	strung.
Swim,	swam, or swum,	swum.
Swing,	swung,	swung.
Wring,	wrung,	wrung.

In many of the foregoing, the original and analogical form of the past time in *a*, which distinguished it from the participle, is grown quite obsolete.

i long into	*ou*,	*ou*.
Bind,	bound,	bound, or bounden.
Find,	found,	found.
Grind,	ground,	ground.
Wind,	wound,	wound.

The following seem to have lost the *en* of the participle in the same manner:

Hang,	hung,	hung.
Shoot,	shot,	shot.
Stick,	stuck,	stuck.
Come,	came,	come.
Run,	ran,	run.
Win,	won,	won.

To the irregular verbs are to be added the defective; which are not only for the most part irregular, but are also wanting in some of their parts. They are in general words of most frequent and vulgar use; in which custom is apt to get the better of analogy. Such are the auxiliary verbs; most of which are of this number. They are in use only in some of their times and modes; and some of them are a composition of times of several defective verbs having the same signification.*

* The whole number of verbs in the English language, regular and irregular, simple and compounded, taken together, is about 4200. The whole number of irregular verbs, the defective included, is about 177.

Present.	Past.	Participle.
Am,	was,	been.
Can,	could.	
Go,	went,	gone.
May,	might.	
Must.		
Quoth,	quoth.	
Shall,	should.	
Weet, wit, or wot,	wot.	
Will,	would.	
Wis,	wist.	

There are not in English so many as a hundred verbs (being only the chief part, but not all of the irregulars of the third class), which have a distinct and different form from the past time active, and the participle perfect, or passive. The general bent and turn of the language is towards the other form; which make the past time and the participle the same. This general inclination and tendency of the language seems to have given occasion to the introducing of a very great corruption; by which the form of the past time is confounded with that of the participle in these verbs, few in proportion, which have them quite different from one another. This confusion prevails greatly in common discourse, and is too much authorised by the example of some of our best writers.

Thus it is said, *he begun*, for *he began; he run*, for *he ran; he drunk*, for *he drank;* the participle being used instead of the past time. And much more frequently the past time instead of the participle: as, *I had wrote, it was wrote*, for *I had written, it was written; I have drank*, for *I have drunk; bore*, for *borne; chose*, for *chosen; bid*, for *bidden; got*, for *gotten*, &c. This abuse has been long growing upon us, and is continually making further encroachments; as it may be observed in the example of those irregular verbs of the third class, which change *i* short into *a* and *u*; as, cling, clang, clung, in which the original and analogical form of the past time in *a* is almost grown obsolete; and the *u* prevailing instead of it, the past time is now in most of them confounded with the participle. The vulgar translation of the Bible, which is the best standard of our language, is free from this corruption, except in a few instances; as, *hid* is used for *hidden; held* for *holden*, frequently; *bid* for *bidden; begot* for *begotten;* once or twice: in which, and a few other like words, it may perhaps be allowed as a contraction. And in some of these custom has established it beyond recovery: in the rest it seems wholly inexcusable. The absurdity of it will be plainly perceived in the example of some of these verbs which custom has not yet so perverted. We should be immediately shocked at, *I have knew, I have saw, I have gave*, &c. but our ears are grown familiar with, *I have wrote, I have drank, I have bore*, &c. which are altogether as ungrammatical.

Adverb.

Adverbs are *added to verbs*, and to adjectives, to denote some modification or circumstance of an action, or quality: as the man-

ner, order, time, place, distance, motion, relation, quantity, quality, comparison, doubt, affirmation, negation, demonstration, interrogation.

In English they admit of no variation; except some few of them, which have the degrees of comparison; as, "often, oftener, oftenest;" "soon, sooner, soonest;" and those irregulars derived from adjectives in this respect likewise irregular; "well, better, best;" &c.

An adverb is sometimes joined to another adverb, to modify or qualify its meaning; as, "very much, much too little, not very prudently."

Preposition.

Prepositions, so called because they are commonly *put before* the words to which they are applied, serve to connect words with one another, and to shew the relation between them.

One great use of prepositions in English is to express those relations, which in some languages are chiefly marked by cases, or the different endings of the noun.

Most prepositions originally denote the relations of place, and have been thence transferred to denote by similitude other relations. Thus, *out*, *in*, *through*, *under*, *by*, *to*, *from*, *of*, &c. *Of* is much the same with *from*: "ask *of* me," that is, *from* me: "made of wood;" "Son *of* Philip;" that is, sprung *from* him. *For*, in its primary sense, is in the *stead*, or *place*, of another. The notion of place is very obvious in all the rest.

Conjunction.

The Conjunction connects or *joins together* sentences; so as, out of two, to make one sentence.

Thus, "You, *and* I, *and* Peter, rode to London," is one sentence, made up of these three by the conjunction *and* twice employed; "You rode to London; I rode to London; Peter rode to London." Again, "You *and* I rode to London, *but* Peter staid at home," is one sentence made up of three by the conjunctions *and* and *but*: both of which equally connect the sentences, but the latter expresses an opposition in the sense. The first is therefore called a conjunction copulative; the other a conjunction disjunctive.

Interjection.

Interjections, so called, because they are *thrown in between* the parts of a sentence, without making any other alteration in it, are a kind of natural sounds adopted to express the affection of the speaker.

The different passions have, for the most part, different interjections to express them.

The interjection *O*, placed before a substantive, expresses more strongly an address made to that person or thing; as it marks in Latin what is called the vocative case.

Syntax.

A Sentence is an assemblage of words, expressed in proper form, and ranged in proper order, and concurring to make a complete sense.

The construction of sentences depends principally upon the concord or agreement, and the regimen or government, of words.

One word is said to agree with another, when it is required to be in like case, number, gender, or person.

One word is said to govern another, when it causeth the other to be in some case, or mode.

Sentences are either simple, or compounded.

A simple sentence hath in it but one subject, and one finite verb; that is, a verb in the indicative, imperative or subjunctive mode.

A phrase is two or more words rightly put together, in order to make a part of a sentence; and sometimes making a whole sentence.

The most common phrases used in simple sentences, are the following:

1. Phrase: The substantive before a verb active, passive, or neuter; when it is said, what thing *is*, *does*, or *is done*: as, "I am;" "thou writest;" "Thomas is loved;" where *I*, *thou*, *Thomas*, are the nominative cases; and answer to the question, *who* or *what?* as, "Who is loved? Thomas." And the verb agrees with the nominative case in number and person; as, *thou* being the second person singular, the verb *writest* is so too.

2. Phrase: The substantive after a verb neuter or passive: when it is said, that such a thing *is* or *is made*, or *thought*, or *called*, such *another thing*; or when the substantive after the verb is spoken of the same thing or person with the substantive before the verb: as, "A calf becomes an ox;" "Plautus is accounted a poet;" "I am he." Here the latter substantive is in the nominative case, as well as the former; and the verb is said to govern the nominative case: or, the latter substantive may be said to agree in case with the former.

3. Phrase: The adjective after a verb neuter or passive, in like manner: as, "life *is short*, and art *is long*." "Exercise *is esteemed wholesome*."

4. Phrase: The substantive after a verb active, or transitive; as, when one thing is said to *act* upon, or *do* something to, another: as, "to open a door;" to build a house:" "Alexander conquered the Persians." Here the thing acted upon is in the objective case: as it appears plainly when it is expressed by the pronoun, which has a proper termination for that case; "Alexander conquered *them*: and the verb is said to govern the objective case.

5. Phrase: A verb following another verb; as, "boys love to play:" where the latter verb is in the infinitive mode.

6. Phrase: When one thing is said to belong to another: as, "Milton's poems;" where the thing to which the other belongs,

is placed first, and is in the possessive case; or else last, with the preposition *of* before it: as, "the poems of Milton."

7. Phrase: When another substantive is added to express and explain the former more fully: as, "Paul the apostle;" "King George:" where they are both in the same case; and the latter is said to be put in apposition to the former.

8. Phrase: When the quality of the substantive is expressed by adding an adjective to it; as, "a wise man;" "a black horse." Participles have the nature of adjectives; as, "a learned man;" "a loving father."

9. Phrase: An adjective with a verb in the infinitive mode following it: as, "worthy to die;" "fit to be trusted,"

10. Phrase: When a circumstance is added to a verb, or an adjective, by an adverb: as, "You read well:" "he is very prudent."

11. Phrase: When a circumstance is added to a verb, or an adjective, by a substantive with a preposition before it; as, "I write for you;" "he reads with care;" "studious of praise;" "ready for mischief."

12. Phrase: When the same quality in different subjects is compared: the adjective in the positive having after it the conjunction *as;* in the comparative, the conjunction *than;* and in the superlative, the preposition *of;* as, "white as snow;" "wiser than I;" "greatest of all."

The principal parts of a simple sentence are the agent, the attribute, and the object. The agent is the thing chiefly spoken of; the attribute is the thing or action affirmed, or denied of it: and the object is the thing affected by such action.

Two or more nouns in the singular number, joined together by one or more copulative conjunctions, have verbs, nouns, and pronouns, agreeing with them in the plural number: as, "*Socrates and Plato were* wise; *they were* the most eminent *philosophers* of Greece." But sometimes, after an enumeration of particulars thus connected, the verb follows in the singular number; and is understood as applied to each of the preceding terms: as, "the glorious inhabitants of these sacred palaces, where nothing but light and blessed immortality, no shadow of matter for tears, discontentments, griefs, and uncomfortable passions to work upon; but all *joy*, *tranquillity and peace*, even for ever and ever, *doth dwell*."—Hooker, B. i. 4. "*sand and salt, and a mass* of iron, *is* easier to bear, than a man without understanding."—Eccles. xxii. 15.

If the singulars so joined together are of several persons, in making the plural pronoun agree with them in person, the second person takes place of the third, and the first of both: "*he and you and I* won it at the hazard of *our* lives: *you and he* shared it between *you*.

The verb *to be* has always a nominative case after it; as, "It *was I*, and not *he*, that did it:" unless it be in the infinitive mode: "though you thought it *to be him*."

The adverbs, *when*, *while*, *after*, *&c.* being left out, the phrase is formed with the participle, independent on the rest of the sen-

tence; as, "The doors being shut, Jesus stood in the midst." This is called the case absolute.

To before a verb is the sign of the infinitive mode: but there are some verbs, which have commonly other verbs following them in the infinitive mode without the sign *to:* as, *bid, dare, need, make, see, hear, feel;* as also *let,* and perhaps a few others; as, "I *bade* him do it; you *dare* not do it; I *saw* him do it; I *heard* him say it."

The infinitive mode is often made absolute, or used independently of the rest of the sentence; supplying the place of the conjunction *that* with the subjunctive mode: as, "*to confess* the truth, I was in fault;" "*to begin* with the first:" "*to proceed;*" "*to conclude;*" that is, "*that I may confess; &c.*"

The infinitive mode has much of the nature of a substantive; expressing the action itself, which the verb signifies; as the participle has the nature of an adjective. Thus the infinitive mode does the office of a substantive in different cases; in the nominative; as, "*to play* is pleasant:" in the objective; as, "boys *love to play.*"

The participle, with an article before it, and the preposition *of* after it, becomes a substantive expressing the action itself which the verb signifies: as, "These are the rules of grammar, by *the observing of* which you may avoid mistakes." Or it may be expressed by the participle, or gerund, "by *observing* which:" not, "by *observing of* which;" nor, "by *the observing* which:" for either of those two phrases would be a confounding of two distinct forms.

The participle is often made absolute, in the same manner, and to the same sense, as the infinitive mode: as, "This, generally *speaking* is the consequence."

The participle frequently becomes altogether an adjective; when it is joined to a substantive merely to denote its quality; without any respect to time: expressing, not an action, but a habit; and, as such, it admits of the degrees of comparison: as, "a learned, a more learned, a most learned man; a loving, more loving, most loving father."

Simple sentences are, 1. Explicative, or explaining: 2. Interrogative, or asking: 3. Imperative, or commanding.

1. An explicative sentence is, when a thing is said to be, or not to be; to do, or not to do; to suffer, or not to suffer; in a direct manner: as in the foregoing examples. If the sentence be negative, the adverb *not* is placed after the auxiliary; or after the verb itself when it has no auxiliary; as, "it *did not* touch him;" or, "it *touched* him *not.*"

2. In an interrogative sentence, or when a question is asked, the nominative case follows the principal verb, or the auxiliary: as, "*was it* he? "*did Alexander* conquer the Persians?" And the adverb *there,* accompanying the verb neuter, is also placed after the verb: as, "*was there a man?*" So that the question depends entirely on the order of the words.

3. In an imperative sentence, when a thing is commanded to be,

to do, to suffer, or not; the nominative case follows the verb or the auxiliary: as, "*go thou* traitor;" or, "*do thou* go;" or the auxiliary *let*, with the objective case after it, is used: as "*let us* be gone."

The adjective in English having no variation of gender or number, cannot but agree with the substantive in those respects; some of the pronominal adjectives only excepted, which have the plural number: as, *those, these:* which must agree in number* with their substantives.

Nouns of measure, number, and weight, are sometimes joined in the singular form with numeral adjectives denoting plurality: as, "fifty *foot;* six *score.*"

"Ten thousand *fathom* deep."

Milton, P. L. ii. 934.

"A hundred *head* of Aristotle's friends."

Pope, Dunciad, iv. 192.

"About an hundred *pound* weight."—John, xix. 39.

The adjective generally goes before the noun: as, "a wise man; a good horse; unless something depend on the adjective; as, "food convenient for me," or the adjective be emphatical; as, "Alexander the Great;" and it stands immediately before the noun, unless the verb *to be*, or any auxiliary joined to it, come between the adjective and the noun: as, "happy is the man; happy shall he be." And the article goes before the adjective: except the adjectives, *all, such*, and *many*, and others subjoined to the adverbs, *so, as*, and *how*: as, "*all the* men;" "*such* a man;" "*many a* man;" "*so good a* man;" "*as good a* man as ever lived;" "*how beautiful a* prospect is here!" And sometimes, when there are two or more adjectives joined to the noun, the adjective follows the noun: as, "a man learned and religious."

There are certain adjectives, which seem to be derived without any variation from verbs, and have the same signification with the passive participles of their verbs: they are indeed no other than Latin passive participles adapted to the English termination: as, *annihilate, contaminate, elate;*

"To destruction sacred and *devote.*—Milton.

"The alien compost is *exhaust.*"—Phillips, Cyder.

These (some few excepted, which have gained admission into common discourse) are much more frequently, and more allowably, used in poetry, than in prose.

The distributive pronominal adjectives, *each, every, either*, agree with the nouns, pronouns, and verbs of the singular number only; as, "the king of Israel and Jehoshaphat, the king of Judah, sat *each* [king] on *his* throne, having [*both*] put on their robes."—1 Kings, xxii. 10. "*Every tree* is known by *his* own fruit."—Luke vi. 44.

---

* By *this means* thou shalt have no portion on this side the river."—Ezra. iv. 16. "It renders us careless of approving ourselves to God by religious duties, and by *that means* seeing the continuance of his goodness."—Atterbury, Sermons. Ought it not to be, by *these means*, by *those means?* or by *this mean*, by *that mean*, in the singular number? as it is used by Hooker, Sidney, Shakspeare, &c.

"Lepidus flatters both,
Of both is flattered; but he neither loves,
Nor *either cares* for him."

Shakspeare, Ant. and Cleop.

Unless the plural noun convey a collective idea; as, "that *every twelve years* there should be set forth two ships."

Bacon.

Every verb, except in the infinitive or the participle, hath its nominative case, either expressed or implied: as,

"Awake, arise, or be for ever fallen:"

that is, "Awake *ye*, &c."

Every nominative case, except the case absolute, and when an address is made to a person, belongs to some verb, either expressed or implied; as in the answer to a question: "Who wrote this book? Cicero:" that is, "Cicero *wrote it*." Or when the verb is understood; as,

"To whom thus Adam:"

that is, *spake*.

Every possessive case supposes some noun to which it belongs: as when we say, "St. Paul's, or St. James's," we mean St. Paul's *church*, or St. James's *palace*.

Every adjective has relation to some substantive, either expressed or implied: as, "the twelve," that is, *apostles*; "the wise, the elect," that is, *persons*.

In some instances the adjective becomes a substantive, and has an adjective joined to it: as, "the chief good;" "Evil, be thou my good!"

In others, the substantive becomes an adjective, or supplies its place; being prefixed to another substantive, and linked to it by a mark of conjunction; as, "sea-water; land-tortoise; forest-tree."

Adverbs have no government.

The adverb, as its name imports, is generally placed close or near to the word which it modifies or affects; and its propriety and force depend on its position*. Its place for the most part is before adjectives; after verbs active or neuter; and it frequently stands between the auxiliary and the verb: as, "he made a *very elegant* harangue; he *spake unaffectedly* and *forcibly*; and *was attentively heard* by the whole audience."

Two negatives in English destroy one another, or are equivalent to an affirmative; as,

"*Nor* did they *not* perceive the evil plight
In which they were, or the fierce pains *not* feel."

Milton, P. L. i. 335.

Prepositions have a government of cases: and in English they always require the objective case after them: as, "*with him; from her; to me*."

The preposition is often separated from the relative which it

---

* Thus it is commonly said, "I *only* spake three words;" when the intention of the speaker manifestly requires, "I spake *only* three words."

governs, and joined to the verb at the end of the sentence or of some member of it: as, "Horace is an author, *whom* I am much delighted *with*." "The world is too well bred to shock authors with a truth, *which* generally their booksellers are the first that inform them *of*." This is an idiom, which our language is strongly inclined to: it prevails in common conversation, and suits very well with the familiar style in writing: but the placing of the preposition before the relative is more graceful, as well as more perspicuous; and agrees much better with the solemn and elevated style.

Verbs are often compounded of a verb and a preposition; as, *to uphold, to outweigh, to overlook:* and this composition sometimes gives a new sense to the verb; as, *to understand, to withdraw, to forgive*. But in English the preposition is more frequently placed after the verb, and separate from it, like an adverb; in which situation it is no less apt to affect the sense of it, and to give it a new meaning; and may still be considered as belonging to the verb, and as a part of it. As, *to cast*, is to throw; but *to cast up*, or to compute, *an account*, is quite a different thing: thus, *to fall on, to bear out, to give over;* &c. So that the meaning of the verb, and the propriety of the phrase, depend on the preposition subjoined.

As the preposition subjoined to the verb hath the construction and nature of an adverb, so the adverbs, *here, there, where,* with a preposition subjoined, as, *hereof, therewith, whereupon,* have the construction and nature of pronouns.

The prepositions *to* and *for* are often understood, chiefly before the pronoun; as, "give me the book; get me some paper;" that is, *to me, for me.*

The preposition *in*, or *on*, is often understood before nouns expressing time: as, "*this day; next month; last year:*" that is, "*on* this day;" "*in* next month;" *in* last year."

In poetry, the common order of words is frequently inverted, in all ways in which it may be done without ambiguity or obscurity.

Two or more simple sentences, joined together by one or more connective words, become a compounded sentence.

There are two sorts of words, which connect sentences; 1. Relatives; 2. Conjunctions.

Examples: 1. "Blessed is the man, *who* feareth the Lord." 2. "Life is short, *and* art is long." 1. and 2. "Blessed is the man, *who* feareth the Lord, *and* keepeth his commandments."

The relatives, *who, which, that,* having no variation of gender or number, cannot but agree with their antecedents. *Who* is appropriated to persons; and so may be accounted masculine and feminine only: we apply *which* now to things only; and to irrational animals, excluding them from personality, without any consideration of sex: *which* therefore may be accounted neuter. But formerly they were both indifferently used of persons: "Our Father, *which* art in heaven." *That* is used indifferently both of persons and things: but it would better become the solemn style to restrain it more to the latter, than is usually done. *What* includes both the antecedent and the relative: as, "This was *what* he wanted;" that is, "*the thing which* he wanted."

The relative is the nominative case to the verb, when no other nominative comes between it and the verb: but when another nominative comes between it and the verb, the relative is governed by some word in its own member of the sentence: as, "the God, *who* preserveth me; *whose* I am, and *whom* I serve;" because in the different members of the sentence the relative performs a different office: in the first member it represents the agent; in the second, the possessor; in the third, the object of an action: and therefore must be in the different cases corresponding to those offices.

Every relative must have an antecedent to which it refers, either expressed, or understood: as, "*Who* steals my purse, steals trash;" that is, "*the man, who*"—

The relative is of the same person with the antecedent: and the verb agrees with it accordingly: as, "Who is *this that cometh* from Edom; *this, that is* glorious in his apparel? *I, that speak* in righteousness."—Isaiah lxiii. 1. "O Shepherd of Israel; *Thou, that leadest* Joseph like a flock; *Thou, that dwellest* between the cherubims."—Psal. lxxx. 1.

When *this, that, these, those,* refer to a preceding sentence; *this,* or *these,* refers to the latter member or term; *that,* or *those,* to the former; as,

"*Self-love,* the spring of motion, acts the soul;
Reason's comparing balance rules the whole;
Man, but for *that,* no action could attend;
And, but for *this,* were active to no end;"

Pope, Essay on Man.

"*Some* place the bliss in action, *some* in ease:
Those call it pleasure, and contentment *these.*"

Ibid.

The relative is often understood, or omitted: as, "The man I love;" that is, *whom* I love.

Conjunctions have sometimes a government of modes. Some conjunctions require the indicative some the subjunctive mode, after them: others have no influence at all on the mode.

Hypothetical, conditional, concessive, and exceptive conjunctions, seem in general to require the subjunctive mode after them: as, *if, though, unless, except, whether, or,* &c.: but by use they often admit of the indicative; and in some cases with propriety. Examples: "*If* thou *be* the Son of God."—Matt. iv. 3. "*Though* he *slay* me, yet will I put my trust in him."—Job xiii. 15.

That, expressing the motive or end, has the subjunctive mode, with *may, might, should,* after it.

Lest, and *that* annexed to a command, preceding; and *if* with *but* following it; necessarily require the subjunctive mode: examples; "Let him, that standeth, take heed *lest* he *fall.*"—1 Cor. x. 12.

When the qualities of different things are compared; the latter noun, or pronoun, is not governed by the conjunction *than,* or *as,* (for a conjunction has no government of cases,) but agrees with the verb, or is governed by the verb, or the preposition, expressed, or

understood. As, "thou art wiser than *I* [am."] "You are not so tall as *I* [am."] "You think him handsomer than [you think] *me;* and you love him more than [you love] *me.*" In all other instances, if you complete the sentence in like manner, by supplying the part which is understood; the case of the latter noun, or pronoun, will be determined. Thus, "Plato observes, that God geometrizes: and the same thing was observed before by a wiser man than *he;*" that is, than *he was.* "It is well expressed by Plato; but more elegantly by Solomon than *him;*" that is, than by *him.*

Interjections in English have no government. Though they are usually attended with nouns in the nominative case, and verbs in the indicative mode; yet the case and mode are not influenced by them, but determined by the nature of the sentence.

PUNCTUATION.

Punctuation is the art of marking in writing the several pauses, or rests, between sentences, and the parts of sentences, according to their proper quantity or proportion, as they are expressed in a just and accurate pronunciation.

As the several articulate sounds, the syllables and words, of which sentences consist, are marked by letters; so the rests and pauses, between sentences and their parts, are marked by points.

But, though the several articulate sounds are pretty fully and exactly marked by letters of known and determinate power; yet the several pauses which are used in a just pronunciation of discourse, are very imperfectly expressed by points.

For the different degrees of connection between the several parts of sentences, and the different pauses in a just pronunciation, which express those degrees of connection according to their proper value, admit of great variety; but the whole number of points which we have to express this variety, amounts only to four.

Hence it is, that we are under a necessity of expressing pauses of the same quantity, on different occasions, by different points; and more frequently, of expressing pauses of different quantity by the same points.

So that the doctrine of punctuation must needs be very imperfect: few precise rules can be given which will hold without exception in all cases; but much must be left to the judgment and taste of the writer.

On the other hand, if a greater number of marks were invented to express all the possible different pauses of pronunciation; the doctrine of them would be very perplexed and difficult, and the use of them would rather embarrass than assist the reader.

It remains, therefore, that we be content with the rules of punctuation, laid down with as much exactness as the nature of the subject will admit: such as may serve for a general direction, to be accommodated to different occasions: and to be supplied, where deficient, by the writer's judgment.

The several degrees of connection between sentences, and between their principal constructive parts, rhetoricians have considered

under the following distinctions, as the most obvious and remarkable: the period, colon, semicolon, and comma.

The period is the whole sentence, complete in itself, wanting nothing to make a full and perfect sense, and not connected in construction with a subsequent sentence.

The colon, or member, is a chief constructive part, or greater division of a sentence.

The semicolon, or half-member, is a less constructive part, or subdivision, of a sentence or member.

A sentence or member is again subdivided into commas, or segments; which are the least constructive parts of a sentence or member, in this way of considering it; for the next subdivision would be the resolution of it into phrases and words.

The grammarians have followed this division of the rhetoricians, and have appropriated to each of these distinctions its mark, or point; which takes its name from the part of the sentence, which it is employed to distinguish; as follows:

The Period	is thus marked	.
The Colon		:
The Semicolon		;
The Comma		,

Other marks used in writing are

The point of Interrogation at the end of a question; as, *who are you?*	?
The point of Admiration or exclamation; as *strange! alas for you!*	!
The Parenthesis, when in the middle of a sentence is introduced a phrase, not necessary to the sense, nor affecting the construction; as	( )

If there's a power above us;
(And that there is, all nature cries aloud
In all her works) he must delight in virtue.

Of the art of grammatical resolution, or accounting for the several parts of speech in a sentence, usually termed parsing, the following example will be sufficient for the reader's information.

The Lord's Prayer.

Our Father who art in heaven! hallowed be thy name; thy kingdom come; thy will be done on earth, as it is in heaven; give us this day our daily bread; and forgive us our trespasses as we forgive them who trespass against us; and lead us not into temptation, but deliver us from evil; for thine is the kingdom, and the power, and the glory, for ever and ever. Amen.

Our a pronoun, first person plural, from the singular *I; Father* a substantive noun, masculine gender and singular number; *who* relative pronoun, also singular and masculine, to agree with *Father;* [In our translation of the New Testament we have *which* in this passage of the Lord's prayer instead of *who*: but *which* is the

neuter gender of the pronoun, and consequently ought not to be applied to any person human or divine;] *art*, the second person singular of the present tense, indicative mode, of the auxiliary verb *to be*; *in* a preprosition; *heaven* a substantive noun, in the objective case, governed by the preposition *in*; *hallowed*, participle past of the passive voice, of the active verb *to hallow*; *be* the third person singular, of the present tense of the subjunctive and imperative modes of the substantive verb *to be*: *hallowed be* is equivalent to *let thy name be hallowed*; or *may thy name be hallowed, reverenced, and held sacred*: *thy* a pronoun of the second person singular, to agree with the following substantive *kingdom*; *come* the third person singular, of the present tense of the imperative and subjunctive modes, of the active verb *to come*; *thy kingdom come* is equivalent to *may* or *let thy kingdom come*: *thy* a pronoun possessive as before; *will* a substantive noun, neuter gender and singular number, nominative case; *be* a verb as before; *done* the participle past of the active verb *to do*; *in* a preposition; *earth* a substantive noun, neuter gender, singular number, and objective case; *as* a conjunction; *it* a pronoun, neuter and singular, agreeing with *will*; *is* third person singular, of the present tense, indicative mode, of the substantive verb *to be*, agreeing with the nominative *it*; *in* a preposition; *heaven* a substantive singular, neuter gender, objective case governed by *in*; *give* second person singular, imperative mode, of the active verb *to give*; the nominative *thou* agreeing with it being suppressed, as *give thou* or *do thou give*; *us* the personal pronoun *I* in the objective case governed by the active verb *give*; *this* an adjective pronoun; *day* a substantive noun, singular number, neuter gender; *our* a possessive pronoun; *daily* a derivative adjective formed from the substantive *day*, agreeing in all circumstances with the following substantive *bread*, of the neuter gender, singular number and objective case, governed by the preceding verb *give*; *and* a conjunction; *forgive*, for *forgive thou* or *do thou forgive*, second person singular, imperative mode, of the active verb *to forgive*, placed in similar circumstances with the foregoing verb *give*, being connected with it by the copulative conjunction *and*; *us* pronoun in the objective case, governed by *forgive*; *our* pronoun; *trespasses* substantive noun, plural number, neuter gender, objective case, agreeing with *our*, and governed by *forgive*; *as* a conjunction; *we* pronoun, nominative plural of *I*; *forgive*, first person plural, present tense, indicative mode, agreeing with *we*; *them* pronoun, plural number, objective case; *who* relative pronoun, agreeing with the antecedent *them*, in being masculine or feminine, and plural, but not in case; for *who* is here the nominative to the following verb *trespass*; [Instead of *who* the pronoun *that* is very commonly but erroneously employed; for *who* is appliable to persons, but *that* belongs properly to things without life;] *trespass* third person plural, present tense, indicative mode, active voice of verb *to trespass*, agreeing with the pronoun before it *who*; *against* a preposition; *us* objective case, plural of personal pronoun *I*; *and* conjunction; *lead* for *lead thou*, or *do thou lead*, second person singular, imperative mode of

active verb *to lead; us* pronoun, governed in the objective case by *lead; not* an adverb; *into* preposition; *temptation* objective case of substantive noun, governed by preposition *into; but* a disjunctive conjunction; *deliver* second person singular, imperative of verb *to deliver*; *us* pronoun; *from* preposition; *evil* an adjective noun here used substantively, and equivalent to *the evil thing, the evil one, evil things in general; for* here used in the place of *because*, a conjunction; *thine* a pronoun; *is* third person singular, present of the indicative of the substantive verb *to be; the* definite article: *kingdom* substantive noun; *power, glory,* substantive nouns; *and* a conjunction: *amen* a Hebrew word indeclinable, signifying properly *truth, verity,* and thence employed in an abridged form to express, *may what has gone before really and truly be brought about!* In the beginning of a sentence, in the New Testament, *amen* signifies *of a truth, truly, verily, indeed.*

In the foregoing exercise, a certain part of the verb called the *imperative* mode, is repeatedly mentioned. This term may surprise the student, as being employed in language denoting not commands, but the most submissive requests and supplications. The reason of this is, that, in the Greek original of the New Testament, as well as in the Latin and other later translations, words are employed to express the humble petitions of the Lord's prayer, which on other common occasions, serve to convey a peremptory command. Thus *give me the bread,* may signify a master's orders to his servant; while in the cases now under consideration, *give us our bread* can signify no more than *we humbly pray thee to give us our necessary food and other comforts.* The term *imperative* therefore is to be taken in its technical and grammatical, and not in its proper literal meaning.

On Reading and Speaking.

Many arguments have been employed to convince the world of a very plain truth, that to be able to speak well is an accomplishment not less useful than ornamental. The importance of a good manner of delivering either one's own sentiments or those of others, must be sufficiently obvious: and every man must allow it to be of some consequence, that what he has occasion to do every hour, ought to be done with propriety. Every private company, and every public assembly will afford opportunites of remarking the difference between a just and graceful manner of delivery, and one faulty and unnatural. The great difficulty however is, not to prove that to be able to read and speak are desireable acquirements, but to point out a practicable and easy way, by which these accomplishments may be acquired.

To follow nature is certainly the fundamental law of good speaking: and without a constant regard to this law, all other rules will, instead of proper elocution, produce only unnatural and affected rant and declamation. Judging from some unlucky specimens of modern studied eloquence, not a few accurate observers have concluded that to follow nature is in fact the only rule to be laid

down; that all artificial rules are at best useless; and that good sense and a cultivated taste are the only requisites to form a good reader or speaker. But in the art of speaking, just as in the art of living, general rules are of little use, until they are unfolded and applied to particular cases: the following plain rules may therefore be of service to the person who is desirous of becoming a correct and graceful reader and speaker.

Rule 1st. *Let your articulation be distinct and deliberate.*

A good articulation consists in giving a clear and full utterance to the several sounds, simple and complex: and much pains is often necessary to become sensible, as well as to gain the mastery of those faults which, although often ascribed to some defect in the organs of speech, are perhaps very generally the consequence of inattention, indolence, or bad example. Almost all persons who have not studied the art of reading and speaking, are apt to utter their words so rapidly, that it is impossible for themselves to place, or for a hearer to perceive the proper stress and accent by which the leading words and syllables in a phrase ought to be distinguished. Till you can read slowly and distinctly, aim at nothing more ornamental.

Learn to speak slow, all other graces
Will follow in their proper places.

Rule 2nd. *Let your pronunciation be bold and forcible.*

An insipid flatness and languor are faults in reading almost universal: and even public speakers by profession, too often suffer the words to drop from their lips, with an utterance so faint and feeble, that they appear neither to feel, nor even to understand what they say, and certainly to be actuated by no very anxious desire that it should be felt or even understood by those who hear them. This is a fundamental fault: a speaker without energy is no better than a lifeless statue: he is even worse; for from a statue we expect no discourse.

In order to acquire a forcible manner of pronouncing your words, accustom yourself, while reading, to draw in as much air as your lungs can contain with ease, that you may have abundance of breath at command, to give force and life to your utterance. It will be of great service to read aloud in the open air, keeping the body as much as possible in an erect posture. Let all the consonants be expressed with a full impulse of the breath and action of the organs engaged in their formation; and let every vowel have its full and bold utterance. In observing this rule however you must take special care not to run into an opposite extreme of loud and boisterous vociferation. This fault is most commonly found among those who, in contempt and despite of all rule and propriety, are determined to be heard and to command attention. It is of such speakers as these that Shakspeare says "they offend the judicious hearer to the soul, by tearing a passion to rags, to very tatters, to

"split the ears of the groundlings;" and the great Roman orator Cicero, compares them to cripples who get on horse-back, because they cannot walk; for they bellow and bawl, because they cannot speak. It was a common remark on a late florid and voluminous speaker in parliament, that in proportion as his ideas refused to supply him with words, his voice swelled in loudness; and that the less he really had to say, with the greater violence he would vociferate.

Rule, 3rd. *Acquire a compass and variety in the height of your voice.*

The monotony or uniform sameness of tone, so much complained of in many readers and speakers, is chiefly owing to the neglect of this rule. They generally content themselves with one certain note or tone of voice, which they employ on all occasions and on all subjects; or if they attempt variety it is only to suit the number of their hearers, or the extent of the place where they speak. Speaking on a higher note or key they imagine to be the same thing with speaking louder; not observing that whether a speaker shall be heard or not depends much more upon the distinctness and force with which he utters his words, than upon the height upon which he pitches his voice. Different kinds of reading and speaking require different heights of voice. Nature instructs us to tell a story, to support an argument, to order a servant, to address a superior, to utter exclamations of anger or indignation, to pour forth lamentations and sorrows, not only with different tones but with different elevations of voice. Men in different ages of life, and in different situations speak in very different keys. The vagrant when he begs, the soldier when he gives the word of command, the watchman when he announces the hour of the night, the sovereign when he issues his edict, the senator when he harangues, the gentle swain when he whispers his tender tale;—these various characters differ not more in the tones they use than in the key or pitch in which they speak. Reading and speaking must therefore, to be correct and natural, have all the varieties adapted to the variety of subjects. But in studying and practising these varieties beware of copying or falling into the pompous bombastic manner of many who exhibit on the theatrical stage (to say nothing of other places), where gerater sense of propriety ought to be felt and displayed.

Rule 4th. *Pronounce your words with propriety and elegance.*

It is not easy to fix on any standard by which to fix the propriety of pronunciation. Mere men of learning, in attempting to make the etymology or derivation of words the rule of speaking, often pronounce words in such a manner as to bring upon them the charge of affectation and pedantry. Mere men of the world, notwithstanding all their politeness, often retain so much of the dialect of their native province, or commit such errors, both in speaking and writing, as must exclude them from the honour of being the models of accurate pronunciation. It is therefore among persons who unite

the two characters of men of learning and men of the world that such a standard can properly be found. The peculiarities and vulgarisms of provincial dialects are chiefly these; omitting the breathing sound of *h* where it ought to be used, and inserting it where it ought not. Not quite a hundred miles from the centre of England persons may be found who will tell you they had been to see a friend and found him sitting in a *harbour* in his garden, reading a letter, giving notice of the arrival of a ship in which he was concerned, in the *arbour* of Liverpool :—confounding and interchanging the letter *v* and *w* : *wery* good *weal* in Essex :—pronouncing the diphthong *ou* like *au*, or like *oo*, and the vowel *i* like *oi* or *e* :—cluttering many consonants together without minding the vowels, &c.

Rule 5th. *Pronounce every word, consisting of more than one syllable, with its proper accent.*

Such a direction is by no means unnecessary, however obvious, because many readers and speakers have affected an uncommon and pedantic mode of accenting words, laying it down as a rule that the accent should be cast as far backward as possible; a rule which has no foundation in the English language, or in the laws of harmony of speech. On the subject of accent and of pronunciation in general, no better guide can be pointed out than the dictionary published some years ago by *Mr. John Walker* of London, particularly the late improved edition by *Mr. Murdoch*, in which students, particularly those at a distance from London will find every requisite instruction.

Rule 6th. *In every sentence distinguish the more significant words, by a natural, forcible, and varied emphasis.*

Emphasis points out the precise meaning of a sentence, shews in what manner one idea is connected with another, marks the several clauses in the sentence, gives to every part its proper sound, and so conveys to the mind of the hearer the full import of the whole. By the proper use of emphasis long and perplexed sentences may appear intelligible and plain: but for this purpose the reader must be perfectly master of the construction and meaning of every sentenee he utters: and it is for the want of this knowledge of the subject that we so often hear persons read with an improper emphasis or stress upon particular words, or with no emphasis at all; that is with a dull unmeaning drawling monotony. In the following words of our Saviour the sense is very different, according to the application of the emphasis to the several words. "Judas betrayest thou the Son of man with a kiss?" *Betrayest* thou implies a reproach for the treachery of Judas :—Betrayest *thou*, regards the intimate connection between Judas, a highly favoured disciple, and his divine master :—Betrayest thou the *Son of man* brings to our view the eminent personal character of the Saviour :—Betrayest thou the son of man *with a kiss*, aggravates in the highest degree the offence of the traitor, in

turning an expression of respect and affection into a signal of destruction.

In order to acquire a habit of speaking and reading with a just and forcible emphasis, nothing more is necessary, than previously to study the construction, meaning, and spirit of every sentence, and to adhere as nearly as possible, to the manner in which we distinguish one word from another, in common conversation. In easy familiar discourse even the unlearned, without effort and without intention, scarcely ever fail to express themselves distinctly, by placing the emphasis on the proper words.

Rule 7th. *Acquire a just variety of pause and cadence.*

One of the greatest faults of a reader or speaker is, to make no other pauses or stops, than what are barely necessary for taking breath. Such a reader can be compared to nothing but an alarm-bell, which, when once set in motion, clatters on incessantly, till the weight that moves it has run down. Without pauses in a discourse the sense must always appear confused and obscure, nay, often be quite lost; and the spirit and energy of the piece be entirely destroyed. In this part of the reader's duty, it is not enough that he scrupulously observe the points used in printing; for these can by no means indicate all the requisite pauses or stops. It is often not only allowable but necessary, for the sake of the more strongly pointing out the sense, of preparing the hearers for what is to follow, or of enabling the reader to alter the tone or height of his voice, sometimes to make a pause, even one very considerable, where the printer has pointed out none, and even where none is required by the grammatical construction of the sentence. Before a full pause it has been customary in reading to drop the voice in one uniform manner; and this has been called the *cadence*, falling or sinking of the voice. But surely nothing can be more destructive of all propriety and energy than this habit. The tones and heights of the voice, at the close of a sentence, ought to be infinitely diversified, according to the general nature of the discourse, and the particular construction and meaning of the sentence. In plain narrative, but especially in argumentation, the least attention to the manner in which we relate a story or a piece of news, or support an argument in conversation, will shew that instead of sinking, it is more proper to raise the voice, at the end of a sentence. Interrogatives where the speaker seems to expect an answer, should almost always be raised at the close, to shew that a question is asked: but in passages where the sense contains nothing to require the conclusion to be elevated or emphatical, an easy gradual fall, to shew that the sense is finished, will be proper and graceful.

Rule 8th. *Accompany the emotions and passions which your words express, by correspondent tones, looks, and gestures.*

Emotions and passions have their language as well as ideas: to express the latter is the province of words; to express the former

nature teaches us to employ tones of voice, looks and gestures. When anger, fear, joy, grief, love, hatred, or any other passion arises in the mind, we naturally discover it by the peculiar manner in which we utter our words, by the features of our countenance, and by other natural signs of which the meaning is never misunderstood. Even when we speak without being influenced by any very violent emotion, some kind of feeling usually accompanies our expressions, and this whatever it be, has its own proper external indications. Expression has indeed been so little studied in public speaking, that we seem almost to have forgotten the language of nature, and are ready to consider every attempt to exhibit it as the laboured and affected result of art. Nature however is always the same; and every judicious imitation of it will always please. Nor can any one deserve the name of a good speaker or reader, much less that of a complete orator, until, to distinct articulation, a good command of voice, and a just emphasis, he is able to add the various expressions of emotion and passion. All endeavours to make men orators, by describing to them in words, the manner in which their voice, countenance, and hands, are to be employed, in expressing the passions, must be weak and ineffectual: perhaps the only advice that can be given on this head, with advantage, is this general one. Observe in what manner the several emotions and passions are expressed in ordinary life, or by those who have, with great labour and delicate taste, gained a power of imitating nature. Accustom yourself either to follow the great original itself, or the best copies you can meet with, always however with this special observance that you "o'erstep not the modesty of nature."

It were greatly to be wished that all public speakers would deliver their thoughts and sentiments, either from immediate conception or from memory: for besides that there is an artificial uniformity which almost always distinguishes reading from speaking, the steady fixed posture, and the bending of the head required by reading, are wholly inconsistent with the freedom, ease, and variety of just elocution. But if this be too much to be expected, especially from preachers who have much to compose, and are often called on to speak in public; it would be extremely desireable that they should make themselves so well acquainted with their discourse, as to be able, with a single glance of the eye, to take in several clauses, or the whole of a sentence at once, so that the constraint of reading may not be perceptible.

It remains only to add, that after the utmost pains have been taken to acquire a just manner of reading and speaking, and this with the greatest success, it is no easy matter to carry this art out of the school or the study to the bar, to the senate, or to the pulpit. A young man who has been accustomed to perform frequent exercises in this art in private, cannot easily persuade himself, when he comes before the public, to consider the business he has to perform, in any other light than as a trial of skill and a display of his powers in oratory. Hence the character of an orator has often been treated with ridicule, and even with contempt. We are pleased with the easy graceful movements which the well-bred man has acquired by

learning to dance: but we are offended and disgusted by the affected airs of the coxcomb, who is always exhibiting his formal dancing bow and minuet step. So we admire the manly eloquence and noble ardour of a British legislator, rising up in defence of the rights of his country; the quick recollection, the forcible reasoning, the ready utterance of the accomplished barrister; and the sublime devotion, genuine dignity, and unaffected earnestness of the sacred orator in the pulpit. When, however, a man in either of these capacities so far forgets the ends, and degrades the consequence of his profession, as to set himself forth to public view, under the character of a *spouter*, and to parade it in the ears of the vulgar, with all the pomp of artificial eloquence; though the unskilful may gaze and applaud, the judicious cannot but be grieved and disgusted. Avail yourself then of your skill in the art of speaking: but always employ your powers with caution and modesty; never forgetting that, though it be desirable to be admired as an orator, it is of infinitely more importance to be respected as a wise statesman, an able lawyer, and a learned, a pious, and a truly useful preacher.

CHAP. II.

OF WRITING.

ON THE PARTICULAR ADVANTAGES ARISING FROM EPISTOLARY WRITING.

Heaven first taught letters for some wretch's aid,
Some banish'd lover, or some captive maid;
They live, they speak, they breathe what love inspires,
Warm from the soul, and faithful to its fires,
The virgin's wish without her fears impart,
Excuse the blush, and pour out all the heart,
Speed the soft intercourse from soul to soul,
And waft a sigh from Indus to the pole!

THE art of expressing to the eye, by marks or characters, upon stone, paper, or other substance, the articulated sounds of human language, is of the most remote antiquity. The origin of writing has by some been, very inconsiderately, limited to the engraving of the decalogue on the tables of stone delivered to Moses on mount Sinai. A very slight attention to the previous history of that great lawgiver might have suggested, that the proverbial wisdom of the Egyptians, in which he was instructed, could not have existed without characters or symbols to record the facts and conceptions in which that wisdom consisted. The characters now used all over Europe, not excepting the German, are evidently Roman, and confessedly copied from the Greeks: for even the Russian or Sclavonian letters are either Greek, or of a comparatively modern invention. What we call Italic characters, were first employed by the *Aldi*, celebrated printers of Venice, to imitate current writing, soon after printing was brought into use. The Greeks acknowledged themselves to have been instructed in the use of alphabetic

characters, by Cadmus and his companions from Phœnicia; who, in all probability, drew them from Chaldea, where the human race were first established after the deluge. The Hebrews who inhabited the interior of the country, of which the Phœnicians of Tyre and Sidon occupied the sea-coast, used their original characters until the Babylonish captivity, above 600 years before our Saviour: but having in the course of 70 years laid their own letters aside, they adopted the beautiful square characters of the Chaldeans, among whom they lived; and these are the letters now used by the Jews, which both they and we very improperly call Hebrew. The original Hebrew characters still subsist, on coins struck by their neighbours, imitators, and rivals, the Samaritans: and although plainly of the same family, are yet very unlike the modern Hebrew. The antient Egyptians employed one set of characters for common use, and another for recording their religious, philosophical, and political mysteries and knowledge. This last being employed by the priests, and upon subjects held to be sacred, was distinguished by a title which the Greeks, who visited Egypt for instruction, in very early times, translated by their own term *hieroglyphics*, a word signifying sacred characters. These consist of a succession of figures, representing men and other animals, birds, serpents, fishes, plants, the human eye, and various other emblems, of which the meaning, notwithstanding the labours of the most ingenious and learned men of all ages, still remains concealed. Among the trophies of the British arms in Egypt, under the lamented Abercrombie, in 1801, were a number of inscriptions in hieroglyphics of the most complete kind, now preserved in the British Museum in London. One of these monuments would, it was natural to conceive, furnish a key to open the mysteries of the hieroglyphics. It contains a tripple inscription, in honour of Ptolemy Epiphanes king of Egypt, 250 years before Christ, composed in the common character of that country, in hieroglyphics, and in Greek. This last contains the same sense with the Egyptian, and it is but reasonable to conclude that the hieroglyphics contain also the same sense: no efforts have however yet proved successful in tracing out the correspondence. The Chinese language and character are so absolutely original, that no traces of the most distant relation has yet been perceived to any other tongue, either in structure or form. The characters have no alphabetical arrangement, consisting merely of a prodigious number of marks, apparently of arbitrary formation, and bearing no outward resemblance to the things they are meant to denote. The words of the Chinese language all orignally consist of only one syllable, and still continue so, when two or more are joined together, as in *house-wife*, *tin-man*, *&c*. The whole number of radical words are by some reckoned 484, but by others only 330: and the sense of each is infinitely varied, even when standing alone, by a multitude of accents and tones of the voice, scarcely perceptible by a foreign ear; all which render the acquisition of the Chinese language vastly more difficult than that of any other prevalent in the world.

The art of writing being altogether imitative, is purely mechanical;

it may therefore be said with truth, that every young person may learn to write with regularity and elegance, with accuracy and speed. He has only to follow the counsels of a judicious teacher, and to copy with assiduity the most correct specimens and examples he can procure, to become a proficient in penmanship. In the beginning the learner ought to practise the formation of his letters of a very large size. For in large characters, errors more readily strike the eye, and may consequently be more easily corrected, than in small writing. In writing on a large scale the proportions of the several parts of a letter amongst themselves, and of the broad and fine strokes of which these parts consist, are the most accurately and easily attended to; and he who is expert in forming a large character will, with great facility, descend to the formation of others of a middling or small size. The young penman ought also to lay it down as a law to draw every stroke, and form every letter, with the greatest deliberation. Better restrict yourself to write half a dozen of lines, slowly, carefully, and correctly, than twice as many sheets of paper, in a rapid, rambling, rough way. The student should adopt for a motto the old Greek proverb: *not every great work is a good work; but every good work is a great work: ou to mega eu, alla to eu mega.* It has within these few centuries become the practice in Europe to draw their letters not perpendicular to the line as in Roman print, but inclined from the right above to the left below. This practice first sprung up in Italy, whither literature, science, and the arts, fled for protection, when in the 15th century, Greece and Western Asia were overwhelmed by Mahometan superstition and barbarism; and from whence the cheering light of knowledge spread over the other nations of Europe. In France, Spain, and Italy, the letters stand much more erect upon the line than they do with us: yet we have never ascertained the degree of inclination of our written characters. Much therefore must in this case be left to the judgment and taste of the writer. The most commendable practice seems to be to draw the broad down-strokes so inclined as to form an angle (as the geometricians say) of about 56 degrees with the right-hand part of the line on which you write,—but the practice of the most scientific writers (not the most ornamental) is the only true guide. Having adopted a proper degree of inclination for your letters, they must all have precisely the same slope; that is all the down-strokes must be drawn perfectly parallel to each other, or at an equal distance asunder in their whole length. Letters of the same kind must also be made of exactly equal lengths, whether as *i* and *n*, in round text, they be confined within the lines limiting the body of the writing, or as *b* and *h*, they rise above the upper line, or as *p* and *y* they fall below the under line. Were we to judge from the practice of many approved masters of writing, and even from the engraved examples published for the use of beginners, we should be tempted to suppose that no rule existed for the management of these long letters. It seems however adviseable that long letters such as *d* and *g* should just rise above the upper line, and fall below the under line, bounding the body of the writing, as much as is equal to the space between

these bounding lines. The letter *t* should rise above the upper line half the height of the *d;* and if the long stroke of the *p* be carried above the upper line, as is often done, it should rise to the height of the *t*. Whatever indulgence may be granted to the writer in the size of the first capital beginning a letter, a poem, a discourse, &c. all the other capitals in the body of the work ought to be strictly confined to rise no higher above the body of the writing, than *b* or *k*, or any other long small letters.

With respect to capital letters themselves, when written in succession, they ought to be all of precisely the same length, with the exception of the *G* and the *Y* which should extend their tails below the other letters, to a distance equal to their height. It is also the general practice to extend the tail of the consonant *J*, likewise to the same distance below the line of the other letters. The propriety of this may however be questioned, on a consideration of the nature of the Roman letter from which our *J* is derived. Neither the Romans nor their great masters in literature and science the Greeks, had in their alphabets any such sound as that of our *J* in *John*, or of the soft *G* in *George*. The Romans used only capital letters, and made no distinction between *V* and *U*. The Latin name for *John*, which is borrowed from the Greek, viz. *Joannes* they wrote IOANNES; and the words *Julius imperator* (the emperor Julius Cæsar) they wrote IVLIVS IMPERATOR. But after the introduction of printing, among the nations of western Europe, where the consonant *J* was in use, the letter-founders cast two letters, precisely of the same size, viz. I and J. How the Romans pronounced the I may be seen from IVLIVS, which they sounded like *Yulius*. In writing therefore both *I* and *J* might safely be made of the same length, both resting on the lower line of the body of the writing; and for distinction's sake the vowel *I* might be turned up with a hair-stroke, while the consonant *J* is likewise turned up a little, to end in a point, as is the case in printed characters.

In or order to write conformably to the preceding observations, the learner must with a ruler and black lead pencil, draw across his paper four lines perfectly parallel, that is, every where equally distant; and the distance to correspond to the space allotted for the body of the writing. In the middle of the space between the upper and the second line, another is drawn, to which the *t* must rise, as also the top of the *p*, if that form be adopted: and upon the same middle line the point or dot over the *i*, is to be placed. The *t* is cut on the second line, even with the heads of the body letters *m*, *s*, &c. In ruling the paper for writing, the close marks of the wires used in the manufacture of the paper and the open lines running across them, will be of great service: but the beginner should not trust implicitly to this help: he should mark off, with a pair of compasses, on the margin of the paper, a number of points, at regular distances, and through them draw light pencil-lines, within which the writing must be confined. At first compasses and a plain flat ruler are to be employed; because by them the lines are drawn with the greatest accuracy: but when the writer's eye is more experienced, he may judge of the distance to be left between the

lines, without using compasses; and then for expedition's sake, employ a round ruler, which ought to be perfectly cylindrical, that is of precisely the same thickness in every part of its length. That each line of writing may appear to the best advantage, they should be placed so far asunder that the letters, reaching above and below the body in one row, shall never touch or be confounded with similar letters in the rows before and after it. These observations and counsels may appear unimportant: but it is not sufficient that writing should be merely legible; it ought also to be neat, and even beautiful. If therefore the student of penmanship content himself with a performance, inferior to what he knows to be easily attainable, he may be assured that he will never arrive at even that humble mediocrity, to which he conceives his wishes to be stinted.

All characters in writing are formed by means of two motions of the pen; the one upwards, fine and delicate, and therefore called a *hair stroke*; the other downwards, broad and strong, called a *down stroke*. The proportion between these strokes never has been, and perhaps never can be determined. Still that some sort of proportion ought to be preserved, will be evident to any one who examines letters written, engraved, printed, carved, or painted, in which the proper balance is not maintained. It is likewise to be observed that, in passing from the hair to the broad stroke, the change must be so gradual and regular, that it may be in some measure impossible to say where the former ends, and the latter begins. It is a great fault in writing, as in engraving and printing, that the hair-stroke is made so extremely delicate that, when beheld at a proper distance, the letters seem to consist only of an endless succession of dark lines, at certain intervals, apparently unconnected; because the fine strokes, by which they are in fact joined together, are so over-fine as then to be imperceptible. In fixing the breadth of letters upon a line, the letter *n* is a convenient standard: for one half of *n* will make an *i*, and *n* and *i* will make an *m*. The letters *e* and *o* require as much room as *n*; so do *u* and *v*; but *w* will fill the space of *m*.

Having proceeded thus far in explanation of the rules for writing a fair hand, in this country, it is now necessary only to refer the student to the engraved examples or copies to be found in all respectable stationer's shops. In the plan of a farm or a field, the accuracy of the boundaries, and not the beauty of the drawing, is the object of both landlord and tenant. So in writing, the shape, position, and proportion of the letters, words, sentences, &c. are much more important to the reader than the finest ornaments. Many occasions must, and certainly do occur, when it is out of the power of the man of business to set down upon paper a regular and complete account of the transactions in which he has been engaged. Still, before he go to sleep, he will draw out, at proper length, a statement of those transactions; and he will take care that they shall be duly registered in his books of business, in such a form, and such a character, that neither he himself, who ought to understand his own business, nor the greatest stranger, can be at a loss in trying to understand the whole transaction. In

making a memorandum* of any occurrence generally, to be done in *haste* (for a man of business is never in a *hurry*) expedition is the object in view: but in making the proper entry of the occurrence in regular books and registers, as time can never be wanting, so deliberation and care can never be dispensed with.

Nothing tends more to the acquisition of a good manner of writing than a proper mode of holding the pen, and an attitude of the hand, arm, and whole body, at once natural, easy, and graceful. If a writer suffer himself, or be suffered by his instructor, to contract a stiff, constrained, or awkward manner, in the management of his pen, or the position of his body at the desk, his operations will be as irksome and even painful to himself, as they must be ludicrous or disgusting in the eyes of by-standers. In this, as in every human action in which the influence of habit is of importance, we are constantly to remember the old counsel; to choose and practise what is the best, and custom will make it the most agreeable. The proper attitudes and motions of the body in writing, can be learned much more speedily, and much more effectually, from the instructions and example of a skilful teacher, than from whole volumes on the subject. The most therefore that ought to be expected in this place, can be only some general advices, to be adopted by the good sense of each writer to his own peculiar case. The pen is held in the right hand, between the thumb and the fore and middle fingers. The middle finger partly on the side and partly on the back, opposite to the head of the cut or cradle of the pen, and the fore finger close to it on the back; both quite straight. The thumb supports the other side of the pen, and is a little bent, in order to give it an easy motion. The fourth finger is turned in towards the palm, and the little finger stretched out even with those holding the pen, rests upon the paper, to support the hand. The elbow should be kept so near to the body, as to allow its motion to be easy and unconstrained, neither stiffly touching the side, nor ridiculously sprawling over the table. In this position the pen will be held in a direction pointing to the right shoulder. The arm rests lightly on the table or desk, between the elbow and the wrist: but the breast should never touch either. The pen is held just so firmly as to keep it in its proper place; for if it be griped hard the learner will never acquire ease and expedition in writing.

* This is one of several Latin terms, commonly occurring in English and other modern writings, as well as in conversation. In English to express the plural number, or more than one thing of any sort, we in general add the letter *s* to the name of the thing in the singular number; as *thing*, *things*, *&c.* In Latin the plural is expressed in various ways, according to particular circumstances in the nature of the name. The names of objects ending with the syllable *um* in the singular number, are made to express the plural by changing *um* into *a*. For instance, one single thing which we would lay down in our pocket-book, to be remembered on some future occasion, is in Latin called a *memorandum*: but two or any greater number of things to be remembered are properly expressed by the Latin plural *memoranda*. Other terms of the same description are *datum*, a thing granted or admitted in reasoning, on which an argument may be founded; in the plural *data*, things granted: *erratum* an error or mistake, has in the plural *errata*, errors or mistakes; terms usually employed in books, to point out and correct mistakes in the printing: *stratum* signifying a bed or layer of any sort, in the plural *strata*, beds or layers of substances placed the one upon the other, as the stone in a quarry, the coal in the mine, the earth, gravel, clay, &c. as they appear in opening a canal, or sinking a well.

In selecting examples for imitation, engraved specimens are to be preferred to written: for the engraver working deliberately and mechanically with his tools, and re-touching the plate until his work be to his satisfaction, is able to produce letters, words, and lines, much more regular and uniform in shape and proportion, than any which, unless the writer be singularly accomplished indeed, can be executed by the hand and pen. In printing, Italic as well as Roman characters, each individual letter stands detached by itself: but in writing all the letters of a word are regularly united by delicate hair-strokes, so as apparently to be executed by one continued motion of the pen. This indeed ought to be the case; and the cutting of the *t*, the pointing of the *i* and all other minute operations, necessary for completing the writing, should be reserved till the whole word be executed. This practice of joining letters together is not confined to Europe. The Turks, Arabians, Persians and some other eastern nations, who set a very particular value upon beautiful writing, indulge themselves so much in artificial and ornamental modes of uniting their characters together, that where this is not skilfully done, it gives them a disgust, of which we in these parts of the world can form no idea. These unions of letters can be executed by the pen and the graver alone: with separate printing-types they are impracticable. Hence arises, and long will arise, among the orientals, a very powerful objection to the introduction of European knowledge, religious, scientific, political, and historical, in works issuing from the printing-press, although in their own languages and characters, however correctly and handsomely executed. Among the Mahometans the use of the press, in matters connected with religion, is considered a sort of profanation. Of this great impediment to the introduction of literature into the East, our laudable missionary and Bible societies are, no doubt, sufficiently aware: at the same time that, under the auspices of our East India company, efforts have, for several years, been making, to furnish the natives of their vast dominions in Asia, with printed books, accommodated as much as possible to their various tastes and prejudices.

If it be difficult to give precise and intelligible directions for placing the body and managing the pen in writing, it is still much more difficult to instruct the beginner how to turn a quill into a pen, or how to repair his pen when disordered by use. In this a few practical lessons from a skilful maker and mender will be of more service than any verbal instructions. The following general observations will nevertheless be of service. With the back of the pen-knife scrape the thin scurf from a good goose-quill, particularly on the back, that the slit may be sound and clean. Then cut the quill half through, near the point, on the back, and quite through on the opposite side, half an inch from the point. With the edge of the knife make a very short slit in the back-notch, and with the end of the knife-haft, or another whole quill, by a quick pressure upwards, open the slit to a proper length, which will be fixed by pressing hard on the back of the quill, with the nail of the left thumb. By several applications of the knife the quill is brought into the proper

shape of a pen, ending in a fine point which must be made even, or nibbed, in this way. Place the inside of the nib on the nail of the left thumb, holding the pen between the fore and middle fingers of the same hand. Place the knife upon the nib, and cut it through, by a change of position from a slope to right across; and then by other cuts give the finishing strokes to the pen. It is to be remembered that if, upon trial, the slit or the nib do not answer, they ought not to be scraped; for that always makes them rough or ragged. When the nib therefore requires alteration, it is mended by nibbing just as when first made. The breadth of the nib and the length of the slit are regulated by the breadth and strength of the black down-strokes intended to be written. The learner should accustom himself in writing to bear as lightly as possible on his pen. By this method he will be able at all times to draw not only a fine hair-stroke, but a down stroke of any particular breadth and strength that may be required. For this reason, a hard stiff pen, requiring much pressure to produce effect, will never answer for writing an easy, flowing elegant hand. Another advantage of a soft flexible pen, in a light hand is, that it will last much longer fit for service, than one that is stiff and unyielding in the fingers of a heavy writer. But however desirable economy in pens may be, we no longer live in the days when a man who desires his writing to be agreeable, or even legible, can adopt the following lines of the renowned translator-general, of his time, as he was called, the idefatigable *Dr. Philemon Holland* of Coventry, who having, two centuries ago, written out a large folio volume, with one single pen, recorded the exploit in these words.

"With one sole pen I writ this book,
"Made of a grey-goose quill;
"A pen it was when it I took,
"And a pen I leave it still."

Some inconsiderate and affected admirers of the wonderful *Shakspeare*, have asserted that he never corrected or altered the dramatic scenes that flowed from his prolific pen. This, if it be a fact, proves that the writer wanted time, or wanted spirits, or wanted the necessary means of subsistence, to enable him to alter, amend, efface, numberless passages, which his own better judgment and taste must have condemned: but it by no means testifies that he fell into no errors, or omitted no improvements, to which a man of his singular genius would in other circumstances, have carefully attended.

"Poets lose half the praise they would have got,
"Were it but known what they discreetly blot."

To execute any operation, literary or mechanical, without error or mistake, is beyond all reasonable expectation. The young penman therefore will not be discouraged if, in his first attempts, his performances come much short of his purposes and expectations. When mistakes therefore do occur, he must exert himself to correct what is amiss, and be more careful in future.

Any one may do any common thing in some way, better or worse: it is a few only comparatively, who can do it well. When a wrong

stroke, letter, word, or sentence shall, through inadvertency, find its way into a piece of writing, the error can be remedied by erasing alone. The surface of writing paper is covered with a size or fine glue, which prevents the ink from spreading over the paper. If this surface be taken off, by erasing with a knife, the ink will immediately sink into, and spread through the substance of the paper, producing a blot or blemish hardly afterwards to be removed. To restore this necessary property to the paper, a new solid surface must be produced, which is done in two ways: either by rubbing it with some smooth hard body, to give it a due degree of polish and solidity to bear the ink, or which is much easier, by rubbing into the paper some substances capable of resisting the power of the ink. These are in general, the resins flowing or drawn from trees and other vegetables. The common resin of the fir and pine trees, when dry, and reduced to a fine powder, may be employed in this way, but its yellowish hue does not suit the complexion of paper. Sandarac is also used: it is a resinous extract of the juniper-tree. These substances all go among us under a general name, *pounce*, a corruption of the French *ponce*, signifying *pumice*. a production thrown out by volcanoes; being a real glass, in the form of small brilliant filaments, composing a porous mass, generally much lighter than water. When pumice is powdered, its colour approaches nearer to that of paper, than that of any of the other substitutes. In erasing, the scraper or knife should be applied lightly, but for a considerable time: then the spot is to be well smoothed and polished with the haft or end of the knife, rubbing on a piece of clean paper over the erasure; after which a little pounce is rubbed on the spot with a piece of paper; when the proper letters, &c. may be written in, as if no erasure had taken place.

When the writing is completed and dry, the lead or pencil lines used in ruling the paper, are effaced with a piece of *caoutchouc*, commonly called *Indian rubber*: in the absence of this the crumb of stale wheaten bread answers very well.

Writing Inks.

These are either black or red: but the former is the most in use, as forming the most complete contrast with the white of the paper. When to an infusion of gall-nuts, (a very improper name for a vegetable excrescence, produced on some trees by an insect) some green copperas (procured from iron dissolved in oil of vitriol) is added, a very dark blue substance is thrown down to the bottom of the vessel. This is a combination of the iron of the green vitriol with the acid of the galls, and is the basis of writing ink. But if galls and green copperas only were employed, the black precipitate would all settle to the bottom, leaving the water of the infusion clear and colourless. In order to keep this precipitate suspended in the infusion, gum-arabic is added, which by its viscid and adhesive quality, supports the black substance equally distributed through the whole liquor. The important

qualities of ink are that it be durable and of a good black colour. To attain these qualities, it ought to be the great study of the manufacturer to introduce into his ink a superabundance of astringent matter, (galls,) to oppose the tendency of the iron to a further calcination or oxydation; for it is this process of turning the iron to rust, that changes black ink to brown. For this purpose, it would be a material improvement if some astringent matter were introduced into the substance of the paper itself, in the manufacture. A little strong spirits put into ink will keep it from turning brown: but then it makes it sink and spread in the paper.

Various recipes have been given for composing writing ink; but few are founded on a knowledge of the chemical or other properties of the several ingredients recommended, and of the changes which a course of time and exposure to the air may produce. The following recipe is given in the lectures of the great chemist, the late *Professor Black*, of Edinburgh. Take in the given proportions, of rasped logwood 1 ounce; of best gall-nuts in coarse powder 3 ounces; of gum-arabic in powder 2 ounces; of green vitriol 1 ounce; of rain-water 2 quarts; of cloves in coarse powder 1 drachm. Boil the water with the logwood and gum, down to one half: strain the hot decoction into a glazed vessel: add the galls and cloves: mix the whole well, and cover it up. When nearly cold add the green vitriol, and stir the infusion repeatedly. After some days, decant or strain the ink into a bottle, to be kept close corked, in a dark place.

The following recipe is given by an eminent chemist in France, where, of late years, the beauty and durability of writing ink have become objects of careful and scientific inquiry. Take of Aleppo galls in coarse powder 8 ounces; of logwood in thin chips 4 ounces; of green copperas 4 ounces; of gum-arabic in powder 3 ounces; of blue vitriol one ounce; of sugar-candy 1 ounce. Boil the log-wood and galls together in 12 pounds of water, for 1 hour, or till half the liquid be evaporated. Strain the decoction through a hair sieve or linen cloth, and then add the other ingredients. Stir the mixture till the whole be dissolved, particularly the gum; after which leave it to subside for 24 hours. Then decant the ink, and preserve it in bottles of glass or stone-ware well corked.

Ink is often of a pale colour when first used: but it grows black when exposed to the air. This is owing to its uniting with the *oxygen*, the principle of acidity, and one of the component principles of our atmosphere: for the iron in the green vitriol not being saturated with oxygen, it absorbs still more from the air, and is then converted into the red oxyde, or what we call rust.

Red Ink is usually made in this way: Take of the raspings of Brasil-wood a quarter of a pound, and infuse them for two or three days in vinegar: boil the infusion afterwards for an hour, over a gentle fire, and filter it while hot. Set it again on the fire, and dissolve in it first half an ounce of gum-arabic, and afterwards, of alum and white sugar, each half an ounce.

Printing Ink is in fact a black paint, composed of lamp-black

and linseed oil or sweet oil, boiled so as to acquire considerable consistence and tenacity. The art of preparing this ink is kept a secret: but the obtaining of proper lamp-black seems to be the principal requisite in its composition.

Copper-plate printers use an ink different from the above, in the oil not being so much boiled, and that Frankfort black is used for lamp-black.

Besides the foregoing kinds of ink, of indispensable use in the affairs of life, others are sometimes employed, generally for amusement, but which may, on particular occasions be really useful. These last are called *sympathetic inks*, because they produce no effect until some other substance be applied to them with which they sympathize, or have an affinity. Thus for instance, the infusion of galls and a solution of green vitriol, will produce a black colour: if therefore you write with one of these liquids, and then apply the other to it, the black colour will be produced, just as if the ingredients had been mingled before they were applied to the paper. Other changes of the colours of substances are produced, by exposure to the air and the fire, agreeably to the nature of chemical combinations.

Write with an infusion of gall-nuts; and when you wish the writing to appear, dip it in a solution of green vitriol, or, as it is commonly called, copperas, when the writing will become black. [When this substance was first noticed as a natural production, its green colour occasioned it to be considered as connected with copper, of which the oxyde or rust is of that colour, and hence it was called copperas: it is however now know to be composed of iron and sulphur; and the similar combination of copper with sulphur is in fact not green but blue, or blue vitriol.]

Dissolve some sugar of lead (white lead dissolved in vinegar and evaporated) in water, and write with the liquor. When dry, no writing will be visible. To make it appear, wet the paper with a solution of liver of sulphur, (sulphur and potash melted together,) and the characters will appear immediately of a brown colour. It will be enough only to expose the writing to the vapour of this solution.

Write with a solution of gold in aqua regia, (nitromuriatic acid, a compound of aqua fortis and spirits of sea-salt;) and let the paper dry slowly in the shade. In this state no writing will be seen: but if a sponge be drawn over it, containing tin dissolved in aqua regia, the letters will immediately appear, of a purple colour.

Write with diluted sulphuric acid, (oil of vitriol) and nothing will be seen on the paper: but if it be held to the fire the letters will become black. The same effect will be produced by writing with the juice of lemons or onions, with solutions of sal ammoniac, of green vitriol, and some other substances; but not so easily, nor with so little heat.

If you write with the mineral cobalt dissolved in aqua regia, the letters will be invisible till held to the fire, when they will turn green; and they will again disappear when removed into the cold.

In this manner the writing will appear and disappear at pleasure, and as at your command. An entertaining experiment with this sort of ink is, to make a drawing of a scene in winter, in which the trees are shown bare and leafless; but the foliage is drawn with the solution of cobalt. Upon holding the drawing to the fire, the spectators will be surprised to see the leaves gradually appearing, in all the verdure of spring.

However unimportant and easy to be explained may be these ways of secret writing, another mode becomes a matter of great consequence, being often employed in conveying intelligence from ambassadors and ministers in foreign parts, to their own courts. This species of secret writing is carried on by the means of cyphers, or marks previously agreed upon, between the parties in the correspondence, to whom alone their import is known. In the early times of Greece, we are told that the Lacedæmonians corresponded with their generals in the field, by means of a very simple though secret contrivance. The magistrates caused to be provided two pieces of wood perfectly round and of precisely the same thickness, about six feet long. One of these batons was given to the general, and the other remained with the magistrates. When a communication was to be made between the parties, a long piece of parchment was rolled, in a spiral or screw form, from one end of the roller to the other; and upon it the informations or orders were written, running across the folds of the parchment, which was then taken off the roller and sent to the other party, who applying it accurately to his own roller, was able to read the communication, which to those who were ignorant of the dimensions of the roller would be totally unintelligible,

As the writing in cypher is become an art of importance, the counterpart is still more so, namely the art of decyphering, or reading secret characters. As the characters or marks chosen at pleasure by the parties who employ the cypher, seem to be entirely arbitrary: it would appear impossible to discover their meaning by the most careful examination: but as in all languages certain letters, syllables, and words occur much oftener than others, if the language in which the cypher is written can be discovered, a man much practised in writing and reading one kind of cypher will be able to penetrate the meaning of almost any other that can be employed. No man perhaps attained to a greater proficiency in the art of decyphering than the celebrated geometrician Dr. Wallis. So skilful and expert had he become as to be able to write out the words of papers written in cypher, and in a language with which he was totally unacquainted. Having written out the words, the language was soon known, and the secret contents unfolded.

Short Hand.

This species of writing is known by different names, derived from the Greek language, such as brachygraphy or short-writing, tachygraphy or swift-writing, stenography or narrow close writing. Many and very various systems of this sort of writing have been

given to the world, of which, that practised and published sixty years ago by *Gurney*, but much improved by his descendants of the present day, is esteemed to be among the most rational. Still this system, with all its excellencies, is not devoid of certain defects, inseparable from the employment of marks, signs, and characters, founded not so much upon philosophical principles, as upon the voluntary and arbitrary taste and choice of the founder. A near approach to a character, conveying to the eye of readers of all countries a distinct notion of its meaning, although on a very limited scale, has been made in the marks and signs adopted in the modern system of chemistry. Every simple substance has there its peculiar representative sign; and the compounds of various substances are denoted by a complex sign, made up of the simple signs, representing each component ingredient. But the greatest improvement on short-hand, and indeed the nearest approach to an universal character, intelligible and practicable by men of all nations, has for many years been perfecting and preparing for the public eye, in this country; in which grammatical accuracy, simplicity, and distinctness, are most ingeniously combined with inconceivable facility and rapidity of execution. To give any notion of this improvement in this place is impossible: it must therefore suffice at present to say that, by the use of a dot or other simple mark, applied in a particular way, the several parts of speech, the voices, modes, and tenses of verbs, &c. &c. can be expressed upon paper, with sufficient speed to enable a writer, acquainted with the system, to keep pace with any public speaker whatever. According to the modes of short hand hitherto used, few men have ever been able to take accurately down every word that fell from the speaker's lips; and those few who, by dint of long and incessant practice, have attained so desirable a proficiency in their art, have employed a multitude of arbitrary marks, drawn from their own fancy, with which by constant use they became familiar. Of the meaning of many of those marks all others but the inventor being generally ignorant, it has often happened that, at the decease of the writer, his contractions and signs have remained quite unintelligible. Of this a remarkable instance occurred some time ago in Scotland, where a celebrated mathematician, intending in his old age to publish the geometrical lucubrations of his younger days, drawn up in a short-hand of his own invention, (but which he had long disused,) was constrained to abandon the project, to his mortification and the public loss, being utterly unable to read his own contractions and marks, and no longer in a condition to resume the course of studies necessary to reproduce the work.

The Telegraph.

The violent agitation and impulse given to the human mind, by the disorders which, in 1789, broke out in France, and for the space of 25 years, kept the rest of Europe in constant fermentation, amidst many unprecedented evils, likewise produced some

good, in improved applications of science to the benefit of mankind at large. The telegraph is, in its principle, by no means a modern invention. The name however is new, although borrowed from the Greek, and signifies *to write far off;* that is to communicate intelligence at a distance. Various kinds of telegraphs have been used in France, and other countries on the continent: but that adopted in this kingdom differs in outward form from them all. A strong wooden frame like the case of a large door or window, is divided from top to bottom by another strong piece of timber, parting the frame as it were into two leaves of a door. Each of these is divided into three parts by small shutters moveable upon hinges placed in the uprights, so as to be fixed in any position perpendicular or horizontal, by means of wires and springs communicating with the room below the machine, where are placed the managers of the telegraph. When any communication is to be made all the six shutters are drawn up perpendicularly, so as to fill the whole frame. When the telegraph next in course to the first has given sign of being prepared, by likewise closing up the frame, the manager of the first begins by opening all the shutters but those which, by previous agreement, are to express certain words or sentences, and the second telegraph repeats the same motions of the shutters, which are immediately repeated by the third in the chain, and so on to the extremity where the communication is to be finally communicated. By this contrivance news or orders may be conveyed through a long chain of telegraphs, without the slightest chance of their being known to any persons but to those at the beginning and the end: for the intermediate stations have only to imitate the operations of the first.

The number of shutters in the telegraph being only six, it may perhaps be supposed that but few variations of intelligence can be conveyed by that number: it is however a matter of positive calculation, that, by these, every thing that can be necessary to communicate in that rapid way, may be certainly expressed. If the bells in a steeple be 4, the changes that may be rung upon them are 24: but if 6, the changes will amount to no fewer than 720. Nay, supposing a company consisting of seven persons had agreed to dine together every day, as long as they could be seated at table in an order different from that of any preceding day; it requires all our confidence in the powers of computation, to believe that the seven friends would be constant messmates every day, for the long term of 5040 days, that is 13 years 10 months and 2 weeks. This calculation is however wholly inapplicable to the telegraph; because it is not enough that six words can change places many times, for they must also be so arranged as to form some sense. By this the combinations are exceedingly restricted; besides that, the great variety of matters on which it may be necessary to make communications, must require various sets and classes of terms, to be used as occasions shall present themselves. By means of lights suspended in certain positions, intelligence may be conveyed in the night-time, as well as by the common telegraph in the day.

OF WRITING LETTERS.

After speaking and reading with propriety and gracefulness, the next thing to be considered is the art of writing letters. This art (for an art and a difficult one too it is,) was by the ancient Romans held to be an accomplishment which was to enter necessarily into the general system of education of youth. Of the same opinion have been all those persons of later times, who have turned their attention to the preparation of young people, to acquit themselves with credit in the business and intercourse of the world. Our own admirable *John Locke* observes, that the writing of letters enters so much into all the occasions of life, that no person can avoid shewing himself in compositions of this kind. Occurrences will daily force him to make this use of his pen, which lays open his breeding, his sense, and his abilities, to a more severe examination, than any conversation or verbal discussion. That letter writing has made no greater progress in improvement, than constant experience shows it has done, must be, in a great measure, attributed to its own intrinsic nature, by which it seems to be incapable of subjection to rules. Nor have the instructions of the best qualified writers on the subject gone beyond some general and comprehensive advices, as to what a letter ought to be, balanced by warnings as to what it ought not to be.

The *style of a letter, that is the mode of expression employed in it, must evidently be suited to, and vary with the nature of the subject handled in it. A letter on mercantile, agricultural, or even scientific business, should be written in such order and language, that its contents may be perfectly clear and intelligible to the person to whom it is sent. It should be so long, that is full, as, if possible, to contain every thing that can be foreseen to be necessary for conveying to the reader a just and satisfactory conception of its purport: but particular care should be taken that it contain nothing more. It is in general a fault, (and in peculiar cases, where time is of importance, it may be productive of much evil or inconveniency) when a letter upon business is so deficient in fulness and perspicuity, as to render a course of other letters between the correspondents indispensably necessary to communicate matters which, by a little consideration, might have been sufficiently explained at first. One of the most able and conscien-

* *Style* is borrowed from the Greek stylos, signifying originally an implement used by the ancients in writing. Among the different ways of writing employed by them, one was to cover a tablet or board, with a thin coat of soft wax, and to write, or rather to engrave on this smooth surface, with an instrument of iron, silver, &c. resembling one of our black-lead pencils. Of this instrument one end was made sharp, to form the characters in the wax, and the other terminated in a broad flat knob, like a button. The use of this end was, that when any letter, word, sentence, or passage was faulty, or for some other reason required to be altered or wholly removed, the wax might be rubbed and smoothed down, to its original state, to receive such letters, &c. as it might be proper again to write on it. From this practice of turning the button for the point of the instrument, when any thing was to be effaced or altered, the writer in doing so was said *to turn or change his style*. Hence by a very natural transition, the name of the instrument used in writing, came to be employed to denote the language and spirit, in which that writing was composed and expressed.

tious governors of our colonies in the West Indies, on entering on his administration, made it universally known that, in all memorials, petitions, or other written applications to him, he desired the statements to be so full, distinct, and circumstantial, (keeping out however whatever had no due relation to the business,) that a person in his situation, entirely a stranger to the matter of the application, should find no difficulty in understanding the case, and in deciding thereon. Some time elapsed before an intimation, so singular, and so unlike those of the generality of men in similar situations, who commonly require all representations to be made as *short* as possible, was properly understood and attended to. But as the first full statements were generally found to answer every purpose of the applicants, as well as of the magistrate, the saving of time, attendance, anxiety, and expense, produced effects the most satisfactory and beneficial.

With respect to the degree of fulness of detail in a letter of business, the writer must be governed by this consideration, that while a few hints may be sufficient to recall to his own mind every particular of a matter, often the object of his serious consideration, his letter may go to the hands of another person who, although perhaps not quite ignorant of it, may be then occupied in affairs of a nature very different, and perhaps to himself infinitely more interesting. It is a common observation, and, happy would it be for the world, were it as just as it is common, that every man understands his own business the best. This consideration ought to teach men to be explicit and accurate in their letters, as in their conversation with others, who cannot possess the same advantages. Instead of this, professional men, particularly in law and medicine, have daily and painful experience of the difficulty found in making applicants by word of mouth, as well as by writing, take the trouble to lay before them an intelligible statement of their several cases. How often does it happen, that a story is related, even where the hearer's appression of it is of the utmost importance, in an order directly the reverse of that in which the several parts of the transaction took place! Every hearer of such a statement must know how irksome and unsatisfactory it is: not every man however will take due pains to steer clear of the same error, when it comes to his own turn to be not a hearer, but a relater. It follows from these remarks that a letter of business should exhibit a regular statement of its subject, beginning as far back in point of time, as to include every occurrence or circumstance, necessary for the proper explanation of the business. However common, and therefore readily excused, it may be, to have recourse to a postscript, or even to a second letter, to communicate matters which ought to have appeared in the body of the first; "Oh I had almost forgotten to tell you;"—"I fear that in my last letter I omitted to state;"—and other phrases of the kind, have always an awkward air: unless we admit the propriety of the fashion adopted, as Swift would archly make us believe, by the ladies of his days who, after filling the whole sheet of paper, on every subject but that really in hand, were compelled to crowd into a line or two of a cramped

postscript, the only matters on account of which the letter required to be written at all.

As a letter of business ought to contain a distinct and orderly statement of its subject, so it ought to be written in language plain but clear and expressive, equally remote from affected finery and from meanness and vulgarity. To hit the precise middle point, in such a case, requires good natural sense, judgment, and experience; but in this matter one would much sooner choose, (if we may use the comparison) to copy the grave but substantial garments of the society of friends, than the gaudy fluttering habiliments of the theatrical fop.

According to the nature of the subject, and of the relation subsisting between the correspondents, must be the matter and the language of a letter. A tradesman or shop-keeper orders goods from a general dealer or a manufacturer: a tenant writes to his landlord or the steward, concerning his farm, or to offer to lease another, or to give notice of his intention to leave that which he occupies: a merchant calls in a debt, or explains why it is not in his power to comply with a money transaction in which he is engaged. In these and all other cases of business between men, the writer of the letter goes directly to the point, communicating in as few words as possible, consistent with perspicuity, his intentions, wishes and expectations. Few men are so little acquainted with business as not to have seen a bill of exchange. Now, what is this but a letter upon a particular subject, stripped of all language not necessary to the understanding and performance of the desire or request it contains? That this is the case will be obvious from the following example, in which the words printed in Italics form a bill of exchange, while the others would complete a letter, containing expressions once customary in writings of this kind, but now disused.

Gentlemen, York, 16th. Dec. 1814.

This letter will be delivered to you by Mr. Richard Jones of this city, who has occasion to go to London; and desiring to be furnished with a credit on your house, for such a sum of money as may be necessary for him there, I have to request that you will *pay to Mr. Richard Jones, or his order, on demand, one hundred and fifty pounds,* for *value received* from him by me, and place the same to my account. Mr. Jones being my friend, and a stranger to London, any civilities you may show to him I will consider as bestowed on myself, and will be ready to return them, whenever you shall afford me an opportunity.

Messrs. Hall and Co.
Bankers, Strand,
London.

I am with due regard,
Gentlemen,
your most obedient servant,
George Ellison.

Many collections of forms of letters have been composed and published for the information and guidance of beginners in epis-

tolary correspondence; as have also been volumes of letters which really passed between the parties described. From these last however little instruction can generally be drawn by the learner; because being the production of persons eminent for their rank or station, or for their attainments in science and literature, they very seldom turn upon the subjects and occurrences which are the most frequently important, in the course of ordinary life. The correspondence of persons in these situations is likewise voluntary and of such a nature, as not only to admit but even to require the writers, to give full scope to their scientific and literary powers. Their productions, although apparently intended for the eye of their correspondents alone, bear usually evident marks of being prepared with a view to the possibility of their being, in some measure, laid before the public at large. The letters therefore of such men in such circumstances, instead of containing the easy and natural expression of their sentiments on ordinary subjects, assume the air of formal essays and dissertations, of which the artificial arrangement and laboured style are entirely foreign to the perspicuity and simplicity of manner and language, in which the excellency of epistolary writing consists. Of the multitudes of unnatural, not to say immoral, productions in the epistolary form, under the title of romances and novels, with which certain London presses daily groan, it may be safely asserted that with very few exceptions the models there exhibited are completely inapplicable to the genuine purposes of letter writing. So much so that if we suppress the customary introduction and conclusion of a letter, and for *I* and *you* substitute *he* and *they*, whole volumes of letters will be instantly converted into something of the nature of historical or biographical narration. The manufacturers, (for it is a mechanical operation) of the great mass of these works, who perhaps never in their lives crossed the threshold of a man of fashion, will seldom stoop to entertain their credulous readers with the conversation and adventures of any one under the rank of my Lady and Sir Philibert. To observe the views and motives, the principles and sentiments, the manners and language, attributed to the personages introduced to the reader, one is inclined to adopt the expression of the great prince of Condé, when conversing with a friend on the writers of his time, who, in their histories of states, pretended to penetrate and disclose the secret and mysterious springs by which courts, ministers, and generals were actuated. "These blockheads," said Condé, "make us think, speak, and act, just as they would have done, had they been in our place." From books of this description, therefore, the letter writer can, in general, collect nothing but unnatural and romantic sentiment, arrayed in affected bombastic language.

It is not in moral conduct only, nor in the more important concerns of life alone, that we ought to adhere to the golden rule, "to do to others as we would have them to do to us in similar cases." When we receive a letter on any matter of business, what we principally require and expect is, that the object of the letter be laid before us in a manner at once orderly, distinct, and clear, and in language composed of plain, natural, unaffected, terms, so that neither

form the arrangement nor the expressions, the slightest hesitation may be excited, as to the purpose of the writer, nor any necessity be occasioned, for applying to our correspondent for further and more accurate information on the subject. Were this consideration always in the mind of a writer, it is not to be imagined how much epistolary correspondence would be simplified, and the transactions of business be thereby facilitated.

To present to the beginner forms of letters, applicable to even a few of the various circumstances in life in which they are requisite, would demand a space far beyond the limits of this work: he will therefore be contented with the following samples, on matters of the most common occurrence in business.

Letter from a young hosier, just entering on business for himself, to a manufacturer in Nottingham.

London, Cheapside, No.——
——October, 1814.

Sir,

Having lately served out my time in the house of your old correspondents, Messrs. Burton and Co. in Cornhill, and having, by the death of an aunt in the country, succeeded to a small property, sufficient, with good management, to enable me to begin business as a hosier, I now, by the advice of my late masters, offer myself to deal with you on the usual terms of the trade. You may not, sir, recollect me in Messrs. Burton's warehouse: but those gentlemen will be ready to give you all satisfaction relative to my character and circumstances: and as from the high established reputation of your house, I can rely with confidence on being furnished with every article in the best order and at the most reasonable rate, so I trust you will have no grounds for dissatisfaction with my conduct in our intercourse with one another. The several articles of hosiery now wanted are particularly specified in the inclosed order, which I beg you will forward to me by the earliest opportunity, and for which your bills on me, at the customary time, for the amount, will be duly honoured. If in any way I can be of service to you in London, you will do me a favour in employing me.

I am,
Sir,
your most obedient servant,
EDWARD YOUNG.

Mr. John Norris,
Nottingham.

Mr. Norris's answer to the above.

Nottingham,
Nov. 1814.

Sir,

I duly received your favour of the———of last month, inclosing an order for sundry articles of hosiery, which I have directed to be packed up, as per inclosed invoice, and forwarded by the waggon, which leaves this place on———and ought to arrive in London on——— next. The goods will, I trust, as well as the prices give you that satisfaction which it has always been the great object of this house to secure; and I have no doubt of your punc-

tuality in answering any demands that it may be necessary to make upon you for the value. Although we have never yet had much personal intercourse with one another, yet I am no stranger to the very favourable opinion entertained of you, by your late masters, for fidelity, attention to business, and constant propriety of conduct, while in their service. With such dispositions and principles, aided by the stock you can command in trade, you cannot fail to do well; and it will give me much pleasure to contribute in any way to the success of a young man, whose conduct hitherto seems so much to deserve it.

Mr. Edward Young,
Hosier, No.——
Cheapside,
London.

I am, Sir,
your obliged and obedient servant,
JOHN NORRIS

From Mr. Young to Mr. Norris.

Sir, [*Private*] London,——1815

Herewith I transmit to you my first payment on account of the hosiery furnished to me by you, as per invoice dated the——November last. Part of this payment is a bill drawn by a respectable dealer here, Mr. Robert Vane, on his correspondent Mr. Thomas Atkins of your town, value L.25. In remitting this bill I am concerned to notify that certain rumours are whispered here, as to the security of Mr. A's affairs. You will therefore of course not lose a moment in presenting the bill, that in case of its not being duly honoured the necessary steps may be taken to recover the value from Mr. V. Reports such as that alluded to being destructive of the credit of a man in mercantile business, at the same time that the non-payment of the bill would occasion me some inconvenience at this moment, I have deemed it proper to communicate the whole in confidence to you, sir, where I know it will be secret. In these times when men of extensive dealings and connections, and possessed of much real property, are exposed to the severest losses, it is not to be wondered at if they be brought into very serious embarrassments: and I should never forgive myself were I, even unintentionally, to be the cause of distress or inconveniency to any man, in a line of life in which the most upright conduct cannot always ensure success. Trusting however that my bill will be regularly taken up

I remain,
Sir,
your very humble servant,
EDWARD YOUNG.

Mr. John Norris,
Nottingham.

Mr. Norris's answer

Nottingham, Jan. 1815.

Sir,

Inclosed you have my receipt for the payment of L.75, on account of hosiery, for which I thank you, and particularly for the confidential hint in your letter of the ——instant. To say the truth,

some suspicions on the subject of that hint began to gain ground in this place; but I did not imagine they had already reached London: and it is with sincere pleasure that I can inform you, on unquestionable authority, that every suspicion respecting the solvency of a certain person, is now completely removed; and that as a proof thereof your bill upon him was instantly discharged. Your feelings on this matter are highly to your credit; and wishing sincerely that you may never stand in need of such tenderness yourself,

I remain,
Sir,
your most obedient servant,
JOHN NORRIS.

Mr. Edward Young,
London.

From Mr. Young to Mr. Norris.

London, March, 1815.

Sir,

To a person so long and so deeply concerned in mercantile transactions as yourself it will occasion no surprise that one of my standing should be involved in difficulty, not from an extravagant spirit of speculation, or from an ill-placed confidence in other men, but from my indispensable connection with persons in the full possession of character and credit, and who are themselves the greatest sufferers in the transactions in which I am to a small amount, concerned. When I name those persons you will not be disposed to blame, as imprudent my engagements with them: I mean the house of Messrs.————in Lombard street. By the stoppage of this house, although I am confident it will be but temporary, it will I fear be impossible for me to take up your bill for L. 145, which will become due on the third of May next. If however from your knowledge of my circumstances in general, you can venture to indulge me with more time, and to accept my bill at six months, with interest, you may rely on its being duly honoured. In the hope that this proposal, a very painful one for me to make, and particularly to you, sir, who have always acted so liberally to me, will be agreed to, and that I shall learn so by the return of the post,

I am,
Sir,
your faithful humble servant,
EDWARD YOUNG.

Mr. John Norris,
Nottingham.

Nottingham, March, 1815.

Sir,

I am extremely sorry, but not surprised that you should be exposed to suffer by the disorder in the affairs of a certain house in Lombard street. I speak this the more feelingly that, having for many years carried on business with that house, to a very considerable amount, the balance of my account in their hands, which however I am confident will not be ultimately lost, is an object of great importance to me, especially at this moment, when I have just been

informed of sundry other accidents of a similar sort, by which I fear I must be a serious loser. But notwithstanding these circumstances, so well am I satisfied with your conduct and principles in business, that I have no objection to accepting your bill at six months, in the place of that which falls due on the third of May: and hoping you will soon recover from your present difficulties,

I am, Sir,

Mr. Edward Young,
London.

your very humble servant,
JOHN NORRIS.

The foregoing specimens of letters are confined to a single branch of transactions: but by a little consideration of the manner in which the several subjects are introduced, and of the language employed in introducing them, the reader will, it is trusted, find no great difficulty in adapting that manner, and that language, to any other occurrence in common life.

In the addresses of letters it was formerly the custom to introduce a number of titles now entirely disused. Without going so far back as to the days when a person sent a letter addressed, "To my Excellent and Right Worshipful Friend Sir Timothy Trusman, Knight, at his Lodgings over against St. Dunstan's Church in Fleet Street London. These."—it is now customary in writing to persons of rank to give them simply their title, without adding *Grace, Lordship*, or any similar phrase. The preposition *to* is also generally disused. Hence in writing to a peer of the realm we would simply say—*The Duke of N.————St. James's Square, London.*——The *Earl of C.————South Audley Street, London, &c.*

The most convenient form for a letter is, a sheet of quarto paper, written on three succeeding pages: observing to leave on the middle of the margins of the third page, a space an inch and a half square to receive the wafer or seal. If this be neglected, the wax or wafer must be placed on part of the writing, which will of course be destroyed, thus occasioning blanks in the sense, which have, in many cases been of the greatest importance. In folding up a letter, the modern fashion is at once simple and sensible; at the same time that if any part of the contents are to be kept particularly secret, they may be rendered quite inaccessible to the most prying curiosity. For it is obvious, that a person who is resolved to act so dishonourably, as to endeavour to discover the contents of a letter entrusted to his care and protection, will not be restrained from so base an action by the most intricate form in which the letter can possibly be made up. The most proper way to fold a letter, written on quarto paper, is to turn up two inches of the page, at top and bottom, and then turn over the inner margin which is double paper to within an inch and a half of the open outer margin, which, folded down, will give sufficient hold and space for the application of the wax or wafer. In writing to persons to whom one wishes to mark particular respect, it is customary to inclose the letter in a cover. In this country however such a letter is considered as double, and consequently charged double postage. In France, Italy, and other parts of the continent where a cover to a letter is looked upon to be

indispensable, an additional charge of about one penny only is made, to the regular postage of the letter, from whatever distance it may come.

Memorials, Petitions, &c.

Compositions of this kind partake so far of the nature of epistolary writings that they are employed to convey to one person, or a public body of men, the requests, representations, and remonstrances of one or more individuals who are thence styled memorialists, or petitioners. The distinction between a memorial and a petition consists more in some external than intrinsic circumstances. An application to the king, the regent, or to either house of parliament, is usually styled a petition. An address to the commander-in-chief of the army, from a common soldier, soliciting some special grace or favour, is properly called a petition: but a similar representation from an officer of rank, would be more suitably termed a memorial. In letters we speak in our own name, and address our correspondent in his own name: that is, for ourselves we use the pronouns of the first person *I* and *me*: for our correspondent we use those of the second person *ye* and *you*, or *thou* and *thee*. In a memorial or petition however these pronouns never once appear, the whole writing being composed in the historical manner, in the third person *he* or *they*, whether it regard the memorialist or those he memorials.

Memorials and petitions are written on large long paper, beginning with the proper title of the person or body addressed, followed by a correct description of the memorialist, &c: and each particular clause of the representation is introduced, as a separate paragraph, with the word *that*, the natural consequence of the introductory expression *most humbly showeth*.

Of the ordinary form of a memorial, petition, or similar representation, the following is a specimen.

To the Right Honourable the Lords Commissioners for executing the office of the Lord High Admiral of Great Britain, [or briefly, the Lords Commissioners of the Admiralty,] &c. &c. &c.

The memorial [petition] of A. B. late a Lieutenant in His Majesty's naval service, but for several years past retired upon half pay,

Most humbly showeth,

That the memorialist first entered into His Majesty's naval service, as a midshipman, now twenty-seven years ago, namely on the——of——on board the——commanded by Captain——

That having in due course of time been appointed a Lieutenant on board the——Captain——commander, the memorialist was severely wounded in an action with a French frigate, the ——off the coast of Portugal, on the——of——by which

the memorialist lost a leg, and was also so disabled in the right arm, as to be rendered unfit for actual duty on board ship.

That in consequence of the favourable report of his conduct, by his commanding officers, their Lordships the Commissioners of the Admiralty at that time, were pleased to bestow on the memorialist an annual allowance, in addition to his regular pay.

That notwithstanding this provision, the memorialist, having a wife and seven children to support, in these times when every necessary article of subsistence is risen to a very high price, finds it extremely difficult to maintain himself and family, with decency and ordinary comfort.

That although unable to perform the duties of the profession to which he was bred, and in which he trusts his conduct was not unbecoming his station, the memorialist presumes he might yet be of some service, as a clerk in one of the departments under their Lordships of the Admiralty; in which situation he might be able to procure an augmentation of his income, without any additional burden on the public.

The memorialist therefore humbly requests the Lords Commissioners of the Admiralty, to take his case into their humane consideration, and to grant him such relief as in their wisdom shall seem to be meet. And the memorialist as in duty bound, will ever pray, &c. &c. &c.

London———

[Memorials, &c. may be either signed by the memorialist, or not.]

CHAP. III.

ARITHMETIC.

WHATEVER is in its nature capable of augmentation and diminution, is termed *quantity:* extent, duration, weight, &c. are all quantities: and whatever constitutes quantity, becomes an object of mathematical investigation. That branch of mathematics which considers quantity, as expressed by numbers, is called *arithmetic*, from a Greek term signifying *number;* and may hence be considered as the science of the nature and properties of numbers: its object is to discover sure and easy methods of representing, compounding, and decompounding numbers; by certain operations, constituting *calculation.*

As all calculation is founded on a knowledge of what is called *unity*, it must be observed, that an *unit* is a quantity assumed at pleasure, to serve as the medium or standard of comparison between quantities of the same sort. Thus, when we affirm of two bodies, that the one weighs three pounds, and the other five pounds, we make a pound the standard of comparison, or the unit: but if we say that the first body weighs forty-eight ounces, and the other eighty ounces, we consider the ounce to be the standard or unit.

By numbers we express how many units, or parts of an unit, are contained in any given quantity. If the quantity consist of entire units, the number by which it is expressed, is called a *whole* number, as for example, sixteen, fifty-nine, two hundred and four, &c.: but if the quantity contain only parts of any given unit, as three quarters of a pound, the number is called a *fraction;* and when the quantity consists of entire units and part of an unit, the number expressing it is said to be *fractional*, as nineteen and nine-tenths.

Arithmetic must have been known from the earliest period of society: but although we cannot conceive a nation, nor even a rational individual to have subsisted without a knowledge of numbers, in their most simple application and uses, yet men may have continued for many ages ignorant of the wonderful extent of their powers. The Greeks were the first European nation who cultivated

the art of numbers; and some have imagined, from the terms employed by them, and by the Romans after them, that in their arithmetical operations, they made use of small stones or pebbles: for both the Greek term *psephizo*, and the Latin *calculo*, (from which we have our *calculation*,) are derived from the words in those languages, signifying a pebble, or small stone.

However this may have been, we find the Greeks very early making use of the letters of their alphabet, to represent numbers. Thus the twenty-four letters taken as they stand in the alphabet, with three other characters, introduced in certain places, were made to represent the nine units or *digits*, the nine *tens*, and the nine *hundreds*.

But the difficulty of carrying on arithmetical operations, to much extent, with such characters, may be easily imagined, and is very evident from calculations still remaining in the works of some antient Greek geometricians.

The Romans who drew from the Greeks the chief part of their skill in the sciences; imitated them also in this mode of expressing numbers; but adopting a different arrangement of the alphabetical characters as here shown,

I.	V.	X.	L.	C.	D.
One,	Five,	Ten,	Fifty,	One hundred,	Five hundred,
	M.				

One thousand, &c.

By the repetition and combination of these numeral characters, any number may be expressed. 1st. By the repetition of a character, the value is also repeated, as, III. represent three; XX. twenty; CC. two hundred.

2nd. When a character is followed by one of inferior value, their values are to be added together, as XII. twelve, LV. fifty-five, MDCCCXIV. one thousand eight hundred and fourteen.

3rd. But when a numeral letter of small value is placed before one of a greater, the less is to be subtracted from the greater, in order to have the value of the expression: thus IV. represent four, IX. nine, XL. forty, XC. ninety, CD. four hundred, &c.

In old books we meet with IↃ. instead of D. for 500. and CIↃ. for 1000, but these characters may perhaps have been only inaccurate representations of D and M.

Thousands are also represented by drawing a short line over the numeral character as $\overline{\text{V.}}$ for 5,000, $\overline{\text{L.}}$ for 50,000, $\overline{\text{CCC.}}$ for 300,000.

About the end of the second century, a new species of arithmetic was invented, as is supposed, by the great geometrician and geographer Ptolomy. Its object was to avoid the difficulties occasioned by fractions in the common arithmetic: and in it the unit was divided into 60 equal parts; each of these into 60 others; each of these last again into 60 other parts, and so on: and from these divisions this kind of arithmetic was called *sexagesimal*, or by *sixties*.

The excellent mode of expressing numbers now used, came into Europe from the Arabians, by way of Spain: but those Arabians did not pretend to be the inventors of these symbols, on the con-

trary they owned they were derived from the Indians. The period when these Arabic symbols were introduced into England is uncertain: but inscriptions have been found as far back as in 1090, where they are employed.

The introduction of these new characters did not immediately put an end to the sexagesimal arithmetic, which having been employed in all astronomical tables, was on this account still retained, at least in the fractions, until decimal arithmetic came into use.

The most ancient treatises on arithmetic are certain books of the elements of Euclid, who flourished about 280 years before Christ. About the year 1460. Regiomontanus (or Muller of Koningsberg) in his tables, divided the radius of the circle into 10,000 instead of 60,000 parts; and so far abolished the former sexagesimal arithmetic, of which however a vestige still exists, in the division of time, and of a degree of a great circle; for an hour is divided into sixty minutes, a minute into sixty seconds, a second into sixty thirds, and so on; and a degree is divided and subdivided in the same manner, into parts of the same denominations. The greatest improvement however which any age has produced, in arithmetical operation, is by the invention of *logarithms*; a discovery for which the world was indebted to Baron Napier of Merchiston in Scotland, towards the beginning of the 17th century. By these and other means, arithmetic may now be considered as the science which has attained the nearest to perfection; and in which very important improvements can scarcely be looked for.

Notation.

By *notation* is meant the art of expressing numbers, by a limited set of characters, called *cyphers* or *figures*.

The figures now used, and their powers, are the following, viz.

1.	2.	3.	4.	5.	6.	7.	8.	9.
one,	two,	three,	four,	five,	six,	seven,	eight,	nine.

To these is added 0 to represent **nought*, or the absence or negation of all number or quantity.

To represent all other numbers by means of these figures, it has been agreed on, that ten units should be formed into one aggregate sum, to be called *ten*, with which calculation may be carried on, as by a simple unit; as two tens, three tens, six tens, &c. on to nine tens. To represent these new units the former figures are employed, but placed in a different position, to the left hand of their original place. Thus to represent twenty-four, containing two tens and four units, we write 24: for sixty, or six tens, without any simple units, we write 60: for ninety-nine, 99

* This figure 0 is commonly, but most absurdly called *ought*, which means *something*, instead of *nought* properly meaning nothing. The same figure is also not unfrequently called a *cypher*, another impropriety: for the term *cypher* means any mark or character employed to represent any given quantity, number, or thing. Hence all the arithmetical symbols, 1, 2, 3, &c. as well as 0, are properly cyphers; and arithmetic itself is often styled *cyphering*. If the old English term *nought* be laid aside, the only substitute for it should be *zero*, a term in general use among scientific calculators all over the continent, and now gradually coming into use among ourselves.

For numbers above ninety-nine, on to and including nine hundred and ninety-nine, another series of units is formed in the same way, each of which contains ten of the preceding series, and one hundred of the simple units. This last series is termed *hundreds;* and by it we express any number, as five hundred and sixty-three, thus, 563: nine hundred and nine, thus, 909: that is, nine hundreds, no odd tens, and nine units. Seven hundred would be 700, without either tens or units.

Again, from nine hundred and ninety-nine, by a similar process, we can count to nine thousand nine hundred and ninety-nine: forming a fresh series of units called *thousands,* each containing ten hundreds. Thus, seven thousand four hundred and thirty-five will be written 7435; eight thousand and six, that is eight thousands, no hundreds nor tens, and six simple units, 8006. The year one thousand eight hundred and fourteen, 1814.

For the better understanding of the principles of notation here explained, the following table is given.

Hundreds of Millions	Ten of Millions	*Millions*	Hundreds of Thousands	Tens of Thousands	*Thousands*	*Hundreds*	*Tens*	*Units*	
								1	One.
							2	1	Twenty-one.
						3	2	1	Three hundred and twenty-one.
					4	3	2	1	Four thousand 321.
				5	4	3	2	1	Fifty-four thousand 321.
			6	5	4	3	2	1	654 thousand 321.
		7	6	5	4	3	2	1	Seven millions 654 thousand 321.
	8	7	6	5	4	3	2	1	Eighty-seven millions 654,321.
9	8	7	6	5	4	3	2	1	987 millions, 654,321.

The first column on the right hand contains units, and the figure 1 in that column, represents the number one. The second line consists of 1 unit and 2 tens, or twenty-one; the third line of 3 hundreds, 2 tens, and 1 unit, or three hundred and twenty-one; and in the same manner the lowest line contains 9 hundreds of millions, 8 tens of millions, and 7 millions: in all 987 millions; also 6 hun-

dreds of thousands, 5 tens of thousands, and 4 thousands; in all 654 thousands; and lastly, 3 hundreds, 2 tens, and 1 unit: so that the whole sum expressed by the 9 figures in the lowest line, is nine hundred and eighty-seven millions, six hundred and fifty-four thousands, three hundred and twenty-one.

In the same manner, numeration may be carried on to any extent, as in the following example:

3	*Trillions*	
2	Hundreds of thousands.	of *Billions*.
1	Tens of thousands	
2	Thousands	
3	Hundreds	
4	Tens	
5	*Billions*	
6	Hundreds of thousands	of *Millions*.
7	Tens of thousands	
8	Thousands	
9	Hundreds	
8	Tens	
7	*Millions*	
6	Hundreds	of *Thousands*.
5	Tens	
4	*Thousands*	
3	Hundreds	
2	Tens	
1	Units	

Where 19 figures represent the sum three *trillions*, two hundred and twelve thousand, three hundred and forty-five *billions*, six hundred and seventy-eight thousand, nine hundred and eighty-seven *millions*, six hundred and fifty-four *thousands*, three hundred and twenty-one.

Of Addition.

The fundamental operations of arithmetical calculation are these four; *addition, subtraction, multiplication,* and *division:* or rather, as quantities are susceptible of no other modification but augmentation and diminution; the two last operations, *multiplication* and *division,* are in fact only speedy methods of performing the two first operations, *addition* and *subtraction.*

By addition we assemble and express on paper, the aggregate value of a number of separate quantities. When the quantities or the numbers by which they are expressed, consist of only one place of figures, as when 3, 5, 7, and 9, are to be added together, we say thus; three and five are eight, and seven are fifteen, and nine are twenty-four, writing 2 for the number of tens, and 4 for the remaining units, as in the margin: but when the sums to be added together consist of more than one place of figures, the scholar must be careful to place them so as that units shall

	9
	7
	5
	3
Sum	24

be immediately under units, tens under tens, hundreds under hundreds, &c. as in the annexed example, where the inhabitants of the principal towns of a certain county, being calculated to be 4,386, 2,285, 7,309, 3,025, and 1,766; it is required to know the amount of the population of these five towns.

	Thousands.	Hundreds.	Tens.	Units.
	4	3	8	6
	2	2	8	5
	7	3	0	9
	3	0	2	5
	1	7	6	6
1	8	7	7	1

Write down these several sums, as in the margin; then, drawing a line under the whole, say, 6 and 5 are 11, and 9 are 20, and 5 are 25, and 6 are 31; that is, 3 tens and 1 unit; then write this 1 in the place of units, and *carrying* (as it is termed) the three tens to the second column of figures, say, 3 and 6 are 9, and 2 are 11, and (passing over the nought) 8 are 19, and 8 are 27: here are 2 tens and 7 units, which units are to be written under the second column, and the two tens carried, or added to the third column. Then say, 2 and 7 are 9, and 3 are 12, and 2 are 14, and 3 are 17; where the seven units are to be written under the column now summed up, and the ten is to be carried to the fourth column; saying 1 and 1 are 2, and 3 are 5, and 7 are 12, and 2 are 14, and 4 are 18. This being the last column, the 8 units are written under the figures added together, and the ten comes to occupy an additional place to the left hand: hence we find the whole amount of the population of the five towns to be eighteen thousand seven hundred and seventy-one persons.

It is of the utmost importance in business to be able to perform addition with dispatch and accuracy; the learner ought therefore to practise it repeatedly, with sums of various lengths; and if he can readily add two simple units, (which are also called *digits*) together, he will easily add a digit to a higher number; thus, 6 and 9 are 15, and 36 and 9 are 45.

In summing up a long column of figures, where mistakes may happen, from interruption or other accidents, it is proper to write down the full amount of each column, either on a separate paper, or in the way shown in the margin; by which means, should any error be suspected, each column of figures may be examined separately, without its being necessary to repeat the whole operation.

6258
27
485
38
59209
7518
365
50
25
16
22
5
73900

Here the 1st column amounts to 50, the 2nd to 25, of which the 5 is placed under the 5 tens of the 1st. column: and so on with the others; and by the last addition of these several amounts, the total 73,900 is obtained, in the same way as if the several numbers of tens had been carried to the succeeding column, as before directed.

To ascertain the accuracy of addition, several methods have been devised, as the following: 1st. to repeat the operation, beginning at the top of the column, and adding the figures downwards: 2nd, to divide the column, if it be long, into several portions, and add each separately; the total of these

parts added together, ought to be equal to the total of the whole column taken at once: 3rd, to cut off a line, the uppermost for instance of the account, and then add the remaining lines, the amount of which added to the line cut off, should be the same with the total first found, thus,

	768279
	32589
	27524
	69837
Total of the 4 lines	898229
Total of the 3 lower lines	129950
Total of this last sum and 1st line . .	898229

Whatever be the quantity adopted for the unit, it may be supposed to be divided into a number of equal parts; and these parts may be of any determined magnitude: but if, for example we should say, that the pound of sterling money is divided into 960 farthings, it would be found extremely difficult either to reckon or to form a distinct conception of such a number of individual farthings, or of intermediate sums between 1 and 960. For this reason the pound is first divided into 20 equal parts called shillings; each shilling into 12 equal parts, called pence; and each penny into 4 equal parts called farthings: so that 1 pound will contain 20 shillings, or 240 pence, or 960 farthings.

When a sum is given consisting of one or more units, together with one or more of these subdivisional parts, it is said to be a complex sum; as 25 pounds, 14 shillings, 9 pence, 3 farthings; or written in this manner, £25 .. 14*s*. .. 9*d*. .. 3*qrs*. where the mark £. stands for the Latin term *libra*, a pound in weight, such a quantity of silver having originally been the value of a pound sterling; *sh*. for shillings: *d*. being the first letter of the Latin word *denarius*, a denier or penny; and *qrs*. for *quadrans* meaning in Latin the fourth part of any thing.

A shop-keeper makes out a statement of the debts due to him in this manner.

		20	12	4
	£	S.	D.	qrs.
A's bill amounts to - - - - - - - - - -	36	17	11	3
B's do. to - - - - - - - - - - - - -	127	16	00	0
C's do. to - - - - - - - - - - - - - -	87	13	10	1
D's do. to - - - - - - - - - - - - - -	9	11	09	2
E's do. to - - - - - - - - - - - - - -	58	19	07	1
F's do. to - - - - - - - - - - - - - .	222	12	06	3
G's do. to - - - - - - - - - - - - - -	89	09	11	1
Total amount of bills	£ 633	[illegible]	08	3
Total of six lower lines	£ 596	03	09	3
Proof	£ 633	01	08	3

Here the several denominations must be carefully placed in the same columns, keeping units under units, tens under tens, hundreds under hundreds, &c. Then beginning with the column of farthings on the right hand, say 1 and 3 are 4, and 1 are 5, and 2 are 7, and 1 are 8, and (passing over the 0 nought or zero) 3 are 11 farthings. But as 4 farthings are one penny, and 11 will contain 4 twice and 3 over, the 11 farthings will be 2 pence and 3 farthings. In the column of farthings set down the remaining 3, and carry the 2 pence to the column of pence, and going first up the units say, 2 and 1 are 3, and 6 are 9, and 7 are 16, and 9 are 25, and (passing over the noughts) 1 are 26; to which adding the 3 tens in the column of tens or 30, you obtain 56 pence. But every 12 pence being 1 shilling, and 48 pence being 4 shillings, 56 pence will be 4 shillings and 8 pence over. This 8 pence must be written in the unit's place of the column of pence (filling up the ten's place, with a zero or a dot for regularity's sake) and the 4 shillings are to be carried to the unit's place of the column of shillings, which when added up will come to 41, and by adding the six tens in the place of tens, or 60, the whole will be 101 shillings. But every 20 shillings forming 1 pound, 101 shillings will form 5 pounds and 1 shilling over. This shilling is written in the column of shillings, with a zero or merely a dot before it, and the 5 pounds are carried to the unit's place of the column of pounds which summed up, as also the places of the tens and the hundreds, will give a total of 633 pounds. The whole amount of the seven bills will then stand £633 01 08 3.

The accuracy of addition of sums of money or any other complex numbers and quantities, is proved by the same methods with those pointed out for checking addition of simple integers.

Again, in adding together a number of quantities expressing weight, the mode of proceeding is exactly similar, as in the following example of several quantities of Avoirdupois weight, where the number of units of one denomination composing an unit of the next higher denomination is marked over the respective columns.

		20	4	28	16	16
	Tons	Cwt.	Qrs.	Lb.	Oz.	Dr.
	75	17	3	25	14	12
	82	12	0	17	09	15
	483	09	2	09	13	11
	279	15	1	26	13	14
	76	18	3	22	08	05
	689	11	2	17	15	13
	29	09	3	15	11	08
Total	1717	15	2	24	07	14

The total amount of the several quantities here set down will therefore be 1717 tons, 15 hundred weight, 2 quarters, 24 pounds, 7 ounces, and 14 drams or, as it ought to be written, drachms.

In calculating quantities of various denominations it is necessary to know the precise proportions of each of these to others among themselves: the reader will therefore here find a statement of measures and quantities of various sorts, the most frequently occurring in ordinary life. These measures and quantities are arranged according to the order in which they stand in the nature of things. 1st. Lineal or mere length and extent, 2nd, superficial or length and breadth of surfaces, 3rd, solid or cubic, consisting of length, breadth, and depth or thickness, 4th. capacity, divided into dry and liquid, and 5th, gravity or weight.

I. *Lineal measures* are

1st. Long measure.

3 Barleycorns	make one	Inch
12 Inches		Foot
3 Feet		Yard
16½ Feet or 5½ Yards		Pole, Rod, or Perch
66 Feet, 22 Yards, 4 Poles		Chain, English
220 Yards, 40 Poles, 10 Chains		Furlong
5280 Feet, 1760 Yards, 320 Poles, 80 Chains, 8 Furlong		Mile, English.

In Scotland the denominations of Long measure are the same as in England, but the respective measures are somewhat longer: thus the Scotch yard or ell, consisting of 3 feet, contains 37 English inches, instead of 36; and the Scotch chain contains 24 ells, equal to 74 English feet, instead of 22 yards or 66 feet. The Scotch furlong therefore consists of 246 2-thirds yards instead of 220, and the Scotch mile contains 5920 feet or 1973$\frac{1}{3}$ yards, or very nearly 89$\frac{7}{10}$ chains English.

2nd. Geographical or nautical measure.

60 Seconds	make one	Minute or mile
3 Minutes		League
60 Minutes or 20 Leagues		Degree.

It is not more common than erroneous to consider the geographical or nautical mile as the same with the English statute mile, consequently the marine league as equal to three, and the geographical

degree as equal to 60 English miles. The degree is the 360th part of the circumference of the earth, which, were it a perfectly regular sphere or globe, would contain about 24,913 English miles: consequently each degree would, instead of 60, contain 69½ English miles, and the geographical or nautical mile or minute of a degree would, instead of 5280 feet, consist of 6090 feet English; the league therefore, instead of three English miles, will contain very nearly 3½. On the other hand the league employed all over France, in computing distances upon the road from place to place, is very little more than 2½ English miles, and the *poste* by which distances on post roads are computed, consisting of 2 leagues, is only equal to five, and not to six English miles, as is generally supposed.

The geographical or nautical minute or mile and league, are the same in all parts of the world: but the local measures of distance are very unequal in different countries; a distinction but too little attended to, in modern accounts of travels, voyages, and systems of geography, particularly when translated or compiled from foreign languages. All maps and sea charts are laid down upon scales of geographical and nautical miles of 60 in the degree, unless where it is otherwise expressed. Maps of counties and small districts are frequently constructed with scales of English miles of 69½ in the degree.

3rd. Cloth measure.

2¼ Inches	make one	Nail
4 Nails or 9 Inches	make one	Quarter
4 Quarters	make one	Yard
1¼ Yard or 5 Quarters	make one	Ell English
3 Quarters	make one	Ell Flemish
1½ Yard or 6 Quarters	make one	Ell French
36 Inches	make one	Yard English
37 Inches	make one	Yard or Ell Scotch.

Scotch and Irish linens are bought and sold by the yard English: but Dutch linens are bought by the ell Flemish, and sold by the ell English.

II. *Superficial measures*, commonly termed *Square measure*, and *Land measure*.

144 Square Inches	make one	Square Foot
9 do. Feet	make one	do. Yard
272¼ do. Feet or 30¼ do. Yards	make one	do. Pole or Rod
40 Poles	make one	Rood
4 Roods	make one	Acre
640 Acres	make one	Square Mile.

In Scotland the acre consists of 4 roods, the rood of 40 falls, the fall of 36 square ells, the ell of 9 feet and 73 inches; so that 1 acre is equal to 4 roods, or 160 falls, or 5760 ells, or 54760 square feet Scotch: hence the Scotch acre contains 55056 English feet, whereas the English acre contains only 43560 feet, consequently 4 Scotch acres are a little more than 5 acres English. The regulated statute acre does not prevail over every part of England itself; for in the northern and western countries, as the length of the pole varies between 16½ feet and 28, the acre must of course be greatly different in different quarters. These acres are styled *customary measure.* The customary acre in Wales is about 2 English acres; and the Irish acre is equal to one acre 2 roods and 19¼ poles English. The *arpent* or acre formerly used in France, was equal to 1¼ acre English, or 54450 feet, nearly agreeing with the Scotch acre, which was probably derived from the old French measure.

Plastering, painting, paving, glazing, are computed by superficial or square measure.

III. *Solid or cubic measure.*

1728 Inches	make one	Cubic Foot
27 Feet	make one	do. Yard
40 Feet of round timber, and 50 Feet of hewn do.	make one	Load.

A cube is a solid figure of which all the sides are of equal length, and all the angles are right or square, each side or surface standing perpendicular upon another: 12 inches in the side multiplied by itself, give 144 square inches for the superficial foot, and this again multiplied by 12 will give 1728 solid inches for the cubic foot. Upon this measure is founded the whole system of guaging.

IV. *Measures of capacity.*

1st. Dry measure.

2 Pints	make one	Quart
2 Quarts	make one	Pottle
2 Pottles or 4 Quarts	make one	Gallon
2 Gallons	make one	Peck
4 Pecks	make one	Bushel
4 Bushels	make one	Coomb or Sack
2 Sacks or 8 Bushels	make one	Quarter
5 Quarters or 10 Coombs	make one	Wey or Load
2 Weys	make one	Last.

By this measure corn, salt, seeds, lead, fruit, oysters, and all dry goods are measured.

2nd. Ale or Beer measure.

4 Quarterns	make one	Pint
2 Pints		Quart
4 Quarts		Gallon
8 Gallons		Firkin of Ale
9 Gallons		Firkin of Beer
2 Firkins		Kilderkin
2 Kilderkins		Barrel
1½ Barrel or 54 Gallons		Hogshead
3 Barrels or 2 Hogsheads		Butt
2 Butts		Tun.

In London the firkin of ale contains the proper measure, 8 gallons: but 9 gallons are given for the firkin of beer.

3rd. Wine measure.

4 Quarterns	make one	Pint
2 Pints		Quart
4 Quarts		Gallon
10 Gallons		Anker
18 Gallons		Runlet
42 Gallons		Tierce
63 Gallons or 1½ Tierce		Hogshead
126 Gallons or 2 Hogsheads		Pipe or Butt
252 Gallons, or 4 Hogsheads, or 2 Pipes		Tun.

By this measure wines and the most valuable liquors, &c. are measured and sold. The standard wine gallon in the Guildhall of London, contains 224 cubic inches, as was ascertained by accurate measurement in the year 1698: but the computation that it contained, by supposition, 231 cubic inches is still retained in practice. The ale and beer gallon contains 282 cubic inches: and the difference between the measures of the same name is owing to this circumstance, that the ale gallon is founded on Avoirdupois weight, while the wine gallon is founded on Troy weight. Eight pounds Avoirdupois weight of wheat, being enacted to fill the ale gallon, while the same quantity of Troy weight is to fill the wine gallon.

4th. Coal measure.

4 Pecks	make one	Bushel
3 Bushels		Sack
9 Bushels or 3 Sacks		Strike
36 Bushels, or 12 Sacks, or 4 Strikes		Chaldron
21 Chaldrons		Score.

These are the London measures for coal brought by sea from Newcastle, and other ports in the north of England. Coals from Staffordshire, brought to London by inland navigation, and from Scotland by sea, are sold by weight.

V. *Weight.*

1st. Apothecaries' weight, is the same with the Troy, but differently subdivided thus.

20 Grains	make one	Scruple or	℈
3 Scruples		Drachm	ʒ
8 Drachms		Ounce	℥
12 Ounces		Pound	℔.

By this weight apothecaries mix and make up their medicines: but they buy and sell by Avoirdupois weight.

2nd. Avoirdupois weight.

16 Drachms or Drams	make one	Ounce
16 Ounces		Pound
28 Pounds		Quarter of a Hundred
4 Quarters or 112 Pounds		Hundred weight
20 Hundred weight		Ton.

This weight is used in weighing grocery goods, and heavy articles that are liable to waste, on which account an allowance is always made, when the goods are weighed at different and distant periods.

3rd. Bread. *Avoirdupois.*

		℔.	Oz.	Dr.
The Peck Loaf	should weigh	17	06	0
Half-Peck do.		8	11	0
Quartern do.		4	05	8

4th. Gold coin.

		Troy. Dwts.	Gr.
The Guinea	should weigh	5	9½
Half do.	should weigh	2	16¾
Quarter do.	should weigh	1	8⅜
Piece of 7 Shills.	should weigh	1	18

5th. Hay.

36 Pounds	make one	Common Truss
56 do.	make one	Truss of old Hay
60 do.	make one	do. of new Hay
36 Trusses	make one	Load.

6th. Troy weight.

24 Grains	make one	Pennyweight
20 Pennyweights	make one	Ounce
12 Ounces	make one	Pound.

By this are weighed jewels, gold, silver, amber, and sundry other valuable articles. One pound of Avoirdupois is equal to 1 pound, 2 ounces, 11 pennyweights, 15½ grains of Troy weight.

7th. Wool.

7 Pounds	make one	Clove
14 Pounds or 2 Cloves	make one	Stone
2 Stones	make one	Tod
3 Tods	make one	Pack
182 Pounds or 6½ Tods	make one	Wey
364 Pounds or 2 Weys	make one	Sack
12 Sacks	make one	Last.

To these tables may be annexed the following, concerning time.

60 Seconds	make one	Minute
60 Minutes	make one	Hour
24 Hours	make one	Day
7 Days	make one	Week
4 Weeks	make one	Month
13 Months	make one	Year.

According to this mode of computation, the year would consist of 364 days: but the natural year consists of 365 days, 5 hours, 48 minutes, and 49 seconds, or nearly 365¼ days. This quarter of a day repeated 4 times makes a whole day, so that each 4th year consists of 366 days, and is on that account called Leap year,

because it goes beyond the bounds of ordinary years. Our year having been formed at different periods, and upon no fixed principles, is very irregularly divided into 12 months, constituting the Calendar, and therefore styled Calendar months. The days in each of these months are, January 31, February 28 in common years, and 29 in leap year, March 31, April 30, May 31, June 30, July 31, August 31, September 30, October 31, November 30, December 31. To recollect these numbers, the following lines will be serviceable.

Thirty days have September;
April, June, and November;
All the rest have thirty one,
Excepting February alone,
Which hath but twenty-eight days clear;
And twenty-nine days in leap year.

In the practice of keeping accounts, it must frequently happen that the whole of an account cannot be contained in one page or folio of the book. When this is the case, the custom is to sum up the contents of the page, and write it down at the bottom of the money column, with the words *carried forward* opposite to the sum: and the same sum is entered at the top of the money column of the subsequent page, with the words *brought forward* leading to it. In this manner each page is summed up, and the amount made the first article in the following page, until the whole account be closed, when the amount of the last page of all, as comprehending all the particular summings of the preceding pages, is to be considered as the total amount of the whole account.

OF SUBTRACTION.

By *Subtraction* we mean that operation which discovers the difference between two given quantities, or agreeably to the import of the term, which draws a less sum from a greater, and so points out the quantity remaining behind. Although subtraction be an operation directly opposite to addition, still the numbers must be placed under one another in the same order as before; that is to say, units under units, tens under tens, &c.; the smallest being under the greater. Then beginning at the units' place or right hand figures, which for instance, let be 7 and 4, we say if from 7 units of any sort as shillings, yards, &c. we take away 4, there will remain 3; or the difference between 4 and 7 will be 3. Again, when one figure of the least number happens to be greater than the corresponding figure in the great number over it, as in subtracting 47 from 72; as we cannot take 7 from 2, we borrow 1 ten from the 7 and obtain 12, from which, if 7 be taken, 5 will remain. Then repaying the ten to the 4 we have 5, which, taken from 7, will leave 2. The whole difference therefore between 47 and 72 will be 25.

Example.

From	768295
Subtract	392538
Remainder	375757
Proof	768295

The *subtrahend* or less number, being written under the *minuend* or greater number, we begin at the unit's place on the right hand, and say 8 cannot be taken from 5, but borrowing one ten from the next figure 9, we have 15, from which 8 may be taken, and 7 will remain. Then proceeding to the next figure in the less number, which is 3, to it we carry 1 for the ten borrowed, making it 4, which taken from the 9 in the upper line, we obtain 5 for the remainder. In the same way 5 may be taken from the 2, that is the 12 above, when 7 will remain, and the ten carried to the 2 in the lower line makes it 3, which may be subtracted from 8, and leave 5. The next figure 9 may in the same manner be taken from 6, that is 16, leaving 7; and carrying one to the last figure 3 in the lower line, making it 4, it may be subtracted from the 7 above, and 3 will remain. The result of the operation is, that if from 768295 things of any sort, 392538 be subtracted or taken out, the number left or remaining behind will be 375757.

The proof of subtraction is performed by adding the remainder found to the least number in the example, when the sum will be equal to the greater number given; or again, from the greater number subtract the remainder found, and the new remainder will be equal to the least number first given.

The following examples will serve to shew the mode of subtraction of complex numbers, or numbers of divers denominations.

A merchant retiring from business desires to know what will be the value of his estate, when all his debts are paid.

	£	S.	D.	qrs.
His property is valued at	9783	10	10	1
And his debts amount to	2985	14	08	3
Remaining clear estate	£ 6797	16	01	2
Proof	£ 9783	10	10	1

Beginning at the right hand he takes 3 farthings in the less sum from those in the greater: but as here there is but 1 farthing, he borrows an integer from the next column of money which consists of pence; and 1 penny containing 4 farthings, he adds 4 to 1, and from 5 farthings he takes the 3, leaving 2 farthings for a remainder. This 2 written down the penny borrowed is repaid, or carried to the 8 pence in the less number making it 9, which subtracted from the 10 pence in the greater number, will leave 1 penny to be inserted in the remainder. Nothing having been borrowed nothing is to be carried on; it is then necessary to take the 14 shillings of the lower from the shillings in the upper line: but these being only 10, a pound must be borrowed from the column of pounds, by which step the 10 becomes 30 shillings, from

which 14 may be taken, and 16 will be left. This remainder is entered in the proper place, and the pound carried to 5 will make it 6, which subtracted from the 3, or the 13 in the upper line, will leave 7. In this way proceeding with the pounds, as in the former example of integers, the difference between the two given sums will be found to be £6797 16 01 2 being the clear value of the merchant's property, when all his debts are paid. The accuracy of the subtraction is ascertained as before, by adding the remainder found, to the least sum, when the two together must be equal to the greatest sum.

Multiplication.

Multiplication is to take any given number as often as there are integers in the number by which it is multiplied: thus to multiply 8 by 5, is to take 8 five times, or in other words, it is to add 8 five times together as if the figures stood in a column as in the margin; where the amount of five times 8 is 40. But instead of this repeated addition of a number, which in many cases would be extremely inconvenient, we write down the number to be multiplied as in this example, calling it the *multiplicand*, and under it, beginning at the right hand, that units may stand under units, &c. we write the number denoting how often the value of the multiplicand is to be taken. This last number is called the *multiplicator* or *multiplier*: and observing that 8 repeated 5 times will amount to 40, we say 5 times 8 are 40; which sum is written down as in the margin, and is called the *product*.

	8
	8
	8
	8
	8
Sum	40
Multiplicand	8
Multiplier	5
Product	40

The multiplicand and multiplicator are also termed *factors*.

To assist in performing multiplication, the following table must be well gotten by heart.

MULTIPLICATION TABLE.

1	2	3	4	5	6	7	8	9	10	11	12
2	4	6	8	10	12	14	16	18	20	22	24
3	6	9	12	15	18	21	24	27	30	33	36
4	8	12	16	20	24	28	32	36	40	44	48
5	10	15	20	25	30	35	40	45	50	55	60
6	12	18	24	30	36	42	48	54	60	66	72
7	14	21	28	35	42	49	56	63	70	77	84
8	16	24	32	40	48	56	64	72	80	88	96
9	18	27	36	45	54	63	72	81	90	99	108
10	20	30	40	50	60	70	80	90	100	110	120
11	22	33	44	55	66	77	88	99	110	121	123
12	24	36	48	60	72	84	96	108	120	132	144

This table is formed by repeatedly adding to itself each number from 1 to 12 included: that is, the first line contains numbers formed by the successive addition of 1 to itself, thus 1 and 1 are 2, and 1 are 3, and 1 are 4, and so on including 12. Again, the 4th line is formed by the successive addition of 4 to itself; thus 4 and 4 are 8, and 4 are 12, and 4 are 16, &c. The use of the table is this: suppose it were required to find the amount of 6 added to itself 8 times; that is the product of 6 multiplied by 8. Look along the upper row of figures for the number 6, then in the same way finding down the left hand column the number 8, carry the eye along the line of 8, until you come to the column at the top of which stands the number 6, and in the space formed by the intersection of this column with the line of 8, you will find the number 48, which is the product of 6 multiplied by 8; or which is the same thing, of 8 multiplied by 6; for it is of no importance which of the two factors is called the multiplicand and which the multiplicator, as 6 repeated 8 times, and 8 repeated 6 times, give precisely the same product. In the same way, if it be desired to know the product of 12 multiplied by 7, under the number 12 in the last column to the right hand, and on the line opposite to 7, on the left hand margin, you will find 84; or reversing this process, under 7 and opposite to 12 you will likewise find the same number 84.—To see how many 9 times 11 are; under 11 and opposite to 9 you will find 99; and the same will be seen under 9 and opposite to 11.

If it be required to multiply two numbers both 12, or one or both under 12, the operation will be performed by a simple inspection of the preceding table: but when greater numbers are to be multiplied together, you must write down the multiplicand, as in the margin, and under the units place the multiplicator, which in this case is 8: then beginning with the first figure on the right hand, say 8 times 5 are 40, (see the table) write nought in the unit's place as there are none, reserving the 4 tens to be added on the next step: say again, 8 times 5 are 40, and the 4 tens remaining to be added are 44: write down the 4 which are over the tens, and reserve the 4 tens for the succeeding step. Here we have 8 times 7, equal to 56, and 4 are 60; write down the nought, and go on with 8 times 3 are 24, and 6 reserved are 30, write nought again, reserving the 3 for the next step, which is 8 times 8, equal to 64, and 3 are 67, which sum being the last, is written down entire. The product therefore of 83755 by 8 is the sum 670040.

	83755
	8
Product	670040

	8 3 7 5 5
	8 3 7 5 5
	8 3 7 5 5
	8 3 7 5 5
	8 3 7 5 5
	8 3 7 5 5
	8 3 7 5 5
	8 3 7 5 5
Sum	6 7 0 0 4 0

If the same operation were to be performed by addition, as in the margin, where the multiplicand is repeated 8 times, both the labour and the chances of error would be much increased.

When the multiplier consists of several places of figures, you multiply by each figure separately, observing to place the first figure of each product immediately in the column under that figure by which you multiply. Thus in the example here given, where the number 42876 is to be multiplied by 356. Begin with 6 of the multiplier, saying 6 times 6 are 36, write down the 6 units and carry the 3 tens to the next product, saying, 6 times 7 are 42, and 3 are 45, where the 5 is written down and the 4 to be carried to the next product, and so on to the end of the multiplicand. Then take the figure 5 of the multiplier, and say, 5 times 6 are 30: as there are no units in this case, write 0 in the column immediately under the 5 by which you multiply, and go on, saying, 5 times 7 are 35, and 3 are 38; write down 8 and carry 3 to the next product; and proceed in this way to the end of the multiplicand. Lastly take the figure 3 of the multiplier and begin as before with the first figure of the multiplicand, 3 times 6 are 18, writing the 8 units in the column under the multiplier 3, and carrying the 1 to the next product, and so on. When you have in this manner written down the several sums produced by multiplying the whole multiplicand by each figure of the multiplier, draw a line under the whole, and add the several products together, which will give the amount produced by the multiplication of the multiplicand by the whole multiplier.

```
   42876
     356
--------
  257256
 214380
128628
--------
15263856
--------
```

The reason for beginning the several lines of product, under the respective figures by which you multiply, is this, that, as in the example given, to multiply by the aggregate sum 356, must be the same thing as to multiply by the 3 sums 300, 50, and 6. Let this be done:

```
   42876       42876      42876
     300          50          6
--------     -------     ------
12862800     2143800     257256
--------     -------     ------

  257256  the product of the multiplier   6
 2143800  . . . . . . . . . .            50
12862800  . . . . . . . . .             300
--------                                ---
15263856  . . . . . . . . .             356
--------                                ---
```

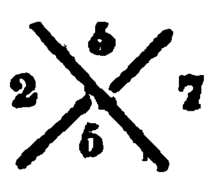
When you have multiplied in the usual way by 6, and set down the product, you come to multiply by 50; and beginning with the 0 supposing it to be an effective figure, it is evident that nought multiplied by 6, or in other words, nought or nothing repeated, 6, or 60, or 600 times, will never produce any positive quantity; write down therefore 0 in the product under the 0 of the multiplier;

and instead of continuing to write a line of noughts, proceed to the next figure 5, employing it in the usual way. In the same manner with the multiplier 300. Beginning with the first 0, write another 0 under it; do the same with the second 0; and then multiply with the figure 3 as before.

Numbers are divided into *prime* and *composite*: a prime number is that which cannot be produced by the multiplication of any two smaller numbers; as 3, 5, 7, 11, and so on; but a composite number is that which may be produced by the multiplication of two smaller numbers; as 4 which is formed by multiplying 2 into 2; 15, the product of 5 multiplied by 3, &c.

To ascertain the accuracy of multiplication, a common method is, to do what is called *throwing out the nines;* as in the example here given:

```
      76385
       6523
     ------
     229155
    152770
   381925
  458310
  ---------
  498259355
```



Make a cross as here shown, then begin to add the figures in the multiplicand, saying 7 and 6 are thirteen, and 3 are sixteen, and 8 are 24, and 5 are 29; which contains three nines, or 27 and 2 over. Write this 2 on the left side of the cross, and add up the multiplier in the same way, which will amount to 16, equal to 1 nine and 7 over; this 7 must be written on the opposite side of the cross; and multiplying the two figures of the cross into one another; 7 times 2 are 14, that is 1 nine and 5 over, which 5 is written in the upper part of the cross: lastly, add up the figures of the product, amounting in this example to 32, (for the two nines are passed over, as in this operation of no consequence,) equal to three nines, or 27 and 5 over: this number being placed in the lower part of the cross, and agreeing with the 5 in the upper part, is a proof that the multiplication is correct; or at least that if there be an error, that error amounts to one or more nines; an accident not very likely to happen.

Contractions in Multiplication.

1st. When the multiplier is a number produced by the multiplication of two others; that is when it is a composite number, you may multiply by the two numbers composing it; thus, to multiply 626 by 48, which is itself the product of 8 by 6, or of 12 by 4, multiply 626 first by 8, and then the product by 6, as in the example.

626	626	626
48	8	12
5008	5008	7512
2504	6	4
30048	30048	30048

2nd. To multiply by 5, which is the half of 10, you may first write down nought in the product, and then annex the half of the multiplicand: as 36 multiplied by 5, give 180; that is the half of 36, with a nought annexed. Again, to multiply by 25, or the fourth part of a 100, annex two noughts and write down in the product the 4th part of the multiplicand. For example, 1744 multiplied by 25 give 43600, equal to the 4th part of 1744 with 00 added.

3rd. When one figure of a multiplier is twice, thrice, four times, &c. or one-half, one-third, one-fourth, &c. of any other figure of the multiplier, then the operation may be shortened, by taking those proportional parts of the products found by the preceding numbers: for instance, in multiplying any sum by 639, when you have wrought with the nine, you may take one-third of the product for the product by three; and doubling this last sum you will have the product by 6.

4th. In multiplying by 9, add 0 to the multiplicand, and beginning with the first figure of it, subtract it from 0, or 10, and so proceed subtracting each subsequent figure of the multiplicand, from the one preceding it, and setting down the remainder as a product; thus in multiplying 436 by 9, you may write or suppose 0 on the right hand of 6, and say six from 10, and 4 remain, which is written down in the product; and then 3 and 1 carried are 4, which taken from 6 leave 2 for the product; 4 from 13 and 9 remain for the product; and carrying 1 for the ten just borrowed, say 1 from the 4 of the multiplicand, and 3 will remain to complete the product.

Compound Multiplication.

Multiplication may be performed not only with integral numbers, as of pounds, tons, &c. but of compound quantities such as pounds, shillings, pence, &c. Tons, hundreds, quarters &c. in this manner: suppose that in dividing the value of a prize at sea, betwen 6 captains, each got £266 .. 17 .. 8 .. 3. What was the value of the whole prize?

	£.	s.	d.	qrs.
Each share	266	17	8	3
Shares				6
Total	£1601	06	4	2

It was already observed that multiplication of integers is only a short method of adding to itself the multiplicand, as often as there are units in the multiplier; the same is true of compound multiplication, as may be seen from this example; for if the share were written down 6 times, and these sums were added together, they would give a total equal to the above product, which is obtained in this way:—6 times 3 are 18 farthings, or four pence 2 farthings; set down the surplus 2, and carry the four to the pence, saying 6 times 8 are 48, and 4 carried are 54 pence, or 4 shillings and 4 pence; write the surplus 4, and carry 4 to the shillings: 6 times 17 are 102, and 4 are 106 shillings, equal to 5 pounds and 6 shillings, which 6 being written in the column of shillings, multiply the 266 pounds by 6, adding the five pounds carried, obtaining a product of £1601 06 4 2 for the total value of the prize.

When the multiplier exceeds 12, or consists of 2 or more places of figures, find its component parts, and multiply the given quantity by one of these component parts, and the product by the other: for example,

	Tons	Cwt.	Qrs.	lbs.	oz.
Multiply	23	12	2	16	12
By 315					9
	212	13	3	10	12
					7
	1488	16	3	19	04
					5
Tons	7444	04	2	12	04

In this example, the multiplier 315 being a compound number, formed the successive multiplication of 9, 7, and 5; multiply the quantity given by one of these component parts, as 9; then multiply the product by another component part, as 7, and the last product by 5, which will give the same result, as if the whole multiplier 315 had been employed at once. It is of no consequence in what order these component parts are used, for 9 multiplied by 7, and the product by 5, will give the same result as if they had been employed in this order, 5, 7, and 9; or 7, 9, and 5, &c.

An application of multiplication, of frequent and great utility in common life, is the method of calculation in measurements, where it is required to ascertain the superficial contents of any surface, of which the dimensions are given in certain measures, as inches, feet, yards, &c. In these operations yards, feet, and inches, may be multiplied into yards, feet, and inches; and the product will consist of quantities of dimensions, similar in name indeed, but totally different in nature. For feet multiplied by feet will give not *lineal* feet of mere length, but *superficial* feet consisting of length and breadth; and if this superficial area be again multi-

plied by lineal feet of depth, height, or thickness, the last product will consist of *solid cubical* feet. To perform this operation, generally called *cross multiplication*, the following table must be well understood.

Table of the products of lineal measurements in yards feet and inches, into yards feet and inches.

Inches multiplied by inches	give	square inches, of which	144 are 1 square foot 1296 1 sq. yard.
Inches by feet Feet by inches		a figure, of which	12 are 1 sq. foot 108 1 sq. yard.
Inches by yards Yards by inches		a figure, of which	4 are 1 sq. foot 36 1 sq. yard.
Feet by feet		square feet, of which	9 are 1 sq. yard.
Feet by yards Yards by feet		a figure, of which	3 are 1 sq. yard.
Yards by yards		square yards.	

The use of this table will be learned from the following example. How many yards of carpeting will cover a room 27 feet 6 inches long, and 18 feet 9 inches broad, supposing the carpet to be just a yard wide?

ft.	in.			ft.		ft.	in.	
27	6			18		27	6	
18	9			6in.		9in.	9in.	
216				108		243	12)54	
27				243				
							4	6
486				12)351(				
29	3			29	3			
	4	6						
9)515	7	6						
57	2	7	6					

The quantity of yard wide carpeting necessary will therefore be 57 yards running and $2\frac{1}{2}$ feet square or nearly $\frac{1}{3}$ yard.

The same result will be obtained by employing yards instead of feet; 27 feet being 9 yards, and 18 feet being 6 yards of lineal measure.

	yds.	ft.	in.				
	9	0	6		9		6
	6	0	9		9		6
	54				81		36
	3	2	3		36		
			4	6	36)117(3		
					108		
yds.	57	2	7	6			
					4)9(2		
					8		
					$\frac{1}{4}$	3	

These calculations are thus performed. The length and breadth being written down in two lines begin by multiplying the 27 feet by the 18, setting down the product 486, which according to the table, must be square or superficial feet, as arising from lineal feet multiplied by lineal feet. Then multiply the 27 feet of the length by the 9 inches of the breadth, giving a product 243: again multiplying the 18 feet of the breadth, by the 6 inches of the length, you will have a product 108. These two quantities being precisely of the same nature, both arising from the multiplication of feet by inches, they may be added together, giving a total of 351. By the table the product of feet multiplied by inches will be regular figures each 1 foot long and 1 inch broad, of which consequently

12 will be equal to 1 square foot. Dividing therefore the sum 351 by 12 we obtain a quotient 29 feet and 3-twelfth parts over. This quantity is written in proper order, under the 486 feet produced by the multiplication of 27 by 18. The last step is to multiply the 6 inches of the length by the 9 inches of the breadth, giving 54 square inches of which, by the table, it requires 144 to make 1 square foot. If therefore we divide the 54 by 12 we obtain the oblong figures above described, of which 12 are 1 square foot, and the remainder are square inches. The product 54 divided by 12 will give 4 for a quotient and 6 for a remainder, to be written in their place as in the preceding example. The whole multiplication being now finished, the several products must be added together amounting to 515 square feet, 7-twelfth parts, and 6 one hundred and forty-fourth parts of a square foot. But as it was required to ascertain the number of yards of carpet, yard wide, that would cover a room of the given dimensions; and as 9 square feet make 1 square yard, we must divide the 515 feet by nine, which will give us 57 yards 2 feet &c. or nearly 57⅓ square yards of carpet: but as the carpet is given yard wide, 57⅓ yards running measure will just cover a floor 27ft. 6in. long, by 18ft. 9in. broad.

The second operation given in the example where, instead of 27 feet, and 18 feet, the equal quantities 9 yards and 6 yards are employed, is performed in precisely the same way, agreeably to the products indicated in the table.

Division.

By division we discover how often one given number is contained in another. The number to be divided is called the *dividend*, the number by which you divide is the *divisor*, and that which expresses how often the divisor is contained in the dividend, is called the *quotient*. If it happen that after the divisor has been taken, as often as it can be, out of the dividend, something be still over, this is called the *remainder*.

Of whatever denomination be the dividend and the divisor, the quotient is either of the same denomination, or an abstract number, as expressing the magnitude of the former sum, relative to the latter: the remainder however is always of the same denomination with the dividend. Thus if we divide £56 among 8 men, the quotient 7 will show the number of pounds given to each man. On the other hand, to know how many yards of silk may be had for £1, when 40 yards cost £10, we divide the 40 yards by the 10 pounds, and the quotient 4 is the number of yards to be purchased by £1.

Multiplication is a short method of performing addition: in the same way division is a short method of performing subtraction. To know, for instance, how often 8 is contained in 32, or how often 8 may be taken out of 32, by subtraction we must work as follows.

This operation would, it is evident be excessively tedious: it has therefore been considered that instead of these repeated subtractions, we may multiply the divisor 8 by any number which will give a product not greater than the dividend 32, as in this example where we see that 8 is contained exactly 4 times in 32; we can therefore multiply the divisor 8 by the quotient 4, and the product will be exactly equal to the dividend 32.

from	32
take	8
	—
1st subtraction	24
	8
	—
2nd subtraction	16
	8
	—
3rd subtraction	8
	8
	—
4th subtraction	0

In division the multiplication table before given, may be used in this way. Taking the same example of dividing 32 by 8, run along the first horizontal line till you come to 8, then going down the column under that figure you will find 32, on a line at the beginning of which, on the left hand, is the figure 4 indicating that 8 is contained 4 times in 32. Again to divide 65 by 7; under the figure 7 find the given number 65 or the nearest lower number, which will be 63: then going along that horizontal line to the left hand margin you will find 9, showing that nine times 7 or 63 is the nearest number less than 65, the difference between them being 2. Hence it appears that 65 divided by 7 will give 9 for the quotient and 2 for the remainder; or in other words that 7 is contained 9 times in 65, with 2 over.

In this manner when the divisor is 12 or less, the multiplication table is serviceable: but when it exceeds 12, we try any multiplier that promises to answer; and if the product be greater than the dividend, the multiplier or the quotient is too great, and a less number must be tried: on the contrary if the product fall short of the dividend by a sum greater than the divisor or just equal to it, then the multiplier in the quotient is too small, and a higher number must be tried. Thus by repeated trials the proper multiplier or quotient is discovered.

Example. Divide 98756 by 6.

Write down the sum to be divided, and making a binding line on each side, place the divisor on the left hand. Then ask how often you can take 6 out of the first figure of the dividend 9: it may be done once: write therefore 1 in the quotient, and multiplying the divisor

```
Div. Divid. Quot.
 6) 98756 (16459
    6····
    —
    ·38
     36
     —
     ·27
      24
      —
      ·35
       30
       —
```

```
·56
 54
 —
 2 Rem.
```

6 by the quotient 1, the product 6 is placed under the 9 of the dividend, and a line being drawn under them, 6 is subtracted from 9, and the remainder 3 is written in its proper place under the 6. The next step is to take down another figure 8 of the dividend, making a dot there to show that it has been taken down. This 8 is written on the right hand of the remainder 3, making a new dividend 38. Next asking how often the divisor 6 can be taken out of 38, it will appear from the multiplication table that 6 times 6 are 36 the nearest number under 38. The 6 is therefore entered in the quotient after the 1, and the 36 placed under 38 with a line below them for subtraction giving the remainder 2. To this number bringing down the next figure of the dividend 7 we have a new dividend 27, in which 6 will be contained 4 times equal to 24. This product subtracted as before from 27 will leave 3 for a remainder, to which 5 being taken down the new dividend 35 is obtained. In this sum 6 will be contained 5 times, making 30, which subtracted from 35, the remainder 5, with the last figure of the dividend 6 brought down, will become a new dividend 56. In this sum 6 is contained 9 times equal to 54, which subtracted from the dividend 56 will leave 2. The result therefore of the whole operation is that in the first dividend 98756, the divisor 6 is contained 16459 times, with 2 over.

In working with a divisor consisting of more than one place of figures, proceed as in the following example. How often can 756 be taken out of 528738?

```
Div.  Divid.  Quot.
756)  528738  (699
      4536··
      ————
      ·7513
       6804
       ————
       ·7098
        6804
        ————
        ·294 Rem.
```

Having written down the divisor and dividend as in the margin, and counting off as many figures from the left hand of the dividend as are in the divisor say, how often can 756 be taken out of 528? This is impossible; we must therefore advance to the next figure in the dividend taking 5287, and again ask the same question. Had the divisor consisted of only one figure 7, it would have been contained 7 times in 52, for 7 times 7 are only 49. Had it even consisted of 2 figures 75 it could have still been taken 7 times out at 528, for 7 times 75 are only 525. But if the whole divisor 756 were multiplied by 7, the product would be 5292, exceeding the given dividend 5287 by 5. We must therefore place the next number 6 in the quotient, and multiplying the whole divisor by it, the product 4536 is written under the corresponding portion of the given dividend and subtracted from it, leaving the remainder 751. To this the next figure of the dividend 3 being brought down, we then try how often the divisor can be

taken out of 7513. This will be found to be 9 times; which figure is placed in the quotient, and by it multiplying the divisor 756 the product 6804 is subtracted from the dividend last formed. To the remainder 709 annexing 8 the last figure of the original dividend, the divisor will be contained in it 9 times again, and the final remainder will be 294. Thus we find that if 528738 be divided by 756, the quotient will be 699 and 294 will be the surplus.

A number which divides another into any number of parts, without leaving any remainder, is called a *measure* of the latter: thus 2, 4, 5, and 10, are all measures of 20; because each of them will exactly divide 20 without any remainder; and these parts or measures are termed *aliquot parts*: hence 1 penny, 2d. 3d. 4d. 6d. are all aliquot parts of a shilling; and 1 shilling, 2s. 4s. 5s. 10s. are likewise aliquot parts of a pound.

To assist in discovering measures of any given number, it is to be remembered that numbers ending with an even figure, as 2, 4, 6, 8, or 0, are all divisible by 2;—that every number ending with 5, or 0, may be measured by 5;—that all numbers of which the figures when added together give an even number of threes or nines, may be measured by three or 9 respectively.

When it happens in division that a remainder, together with the figure brought down from the dividend, is not so great as the divisor, you must write 0 in the quotient, and take down the following figure, to be proceeded with as before. This is to be done, and 0 to be placed in the quotient, as often as the divisor cannot be taken out of the new dividend.

```
7856)58967206704(7506009
     54992······
     ─────
     ·39752
      39280
      ─────
      ··47206
        47136
        ─────
        ···70704
           70704
           ─────
           ·····
```

Here the number to be subtracted in the second division, leaves only a remainder of 472, which, with the 0 brought down from the dividend, being still less than the given divisor, cannot be divided by it; 0 is therefore written in the quotient, and an additional figure 6 is brought down. In this increased dividend, the divisor may be found 6 times; and the product subtracted leaves only 70, to which the figure 7 being brought down, the whole is still too small to be divided by the divisor: 0 is therefore placed in the quotient after 6, and another figure 0 is brought down, making the whole number 7070; but this being still less than the divisor,

another 0 is placed in the quotient, and the last figure of the dividend 4 is taken down, giving a new dividend of 70704. In this increased quantity, the divisor 7856 will be contained just 9 times without any remainder: and the operation is finished.

Contractions in Division.

Division may be shortened in various ways: as for instance, in dividing by any one of the nine digits, or by 10, 11, and 12, write down the divisor and dividend as before,

```
          Dividend                      Dividend
           3  124                        744775
 Div. 5)8536295(0 Rem.     Div. 9)25603976(2 Rem.
        ———————                   ————————
 Quot.   1707259                   2844886   Quot.
        ———————                   ————————
```

and drawing a line under the dividend as here shown in the examples, say 5 in 8 once and 3 over: write 1 for a quotient under the 8, and placing a small 3 over the next figure of the dividend 5, so as to make 35, say 5 in 35, 7 times, and nothing over; then write the 7 in the quotient; and as 5 cannot be taken out of 3, write 0 in the quotient, and adding the following figure 6, take 5 out of 36, 7 times and one over; writing the 7 in the quotient, place the 1 over the next figure 2, and take 5 out of 12, twice and 2 over. Proceeding in this way to the end of the dividend, the quotient will come to be, as in the first example, and there will be no remainder. In the second example where the divisor is 9, the last remainder 2 is written up in the place which, in the long operation of division, would be occupied by the quotient.—The placing of the several remainders, in small characters, over the figures of the dividend, is merely as a help for beginners, and will soon be found unnecessary.

Again, when the divisor and dividend are both compounded of the same number, as in the following example, where both are composed of 8 multiplied by different numbers; divide both divisor and dividend by 8, and then divide the quotient of the dividend, by the quotient of the divisor, and the quotient of this last division, will be the same as if the original numbers had been employed.

```
 8)48(    8)45840(    48) 45840 (955 Quot.
 ————     ————————        432··
   6      6) 5730(        ————
          ————————         ·264
 Quot.       955            240
                           ————
                           ·240
                            240
                           ————
                            ···
```

When the divisor ends with one or more noughts, cut them off, and cut off an equal number of figures, beginning at the unit's

place of the dividend; then dividing by the remaining integers of the divisor, bring down the figures of the dividend that were cut off, to annex to, or form the remainder: thus.

```
56|000) 8379|628 (149
        56··
        ----
        277
        224
        ----
         539
         504
         -----
         35628 Rem.
```

Now, had this division been performed in the ordinary way, as is done below, the quotient and the remainder would have been the same.

```
56000) 8379628 (149
       56000··
       -------
       277962
       224000
       -------
        539628
        504000
       -------
         35628
```

In dividing any sum by 10, 100, 1000, or any other number composed of 1 with noughts after it; all that is necessary is to cut off from the dividend, beginning at the unit's place, as many figures as there are noughts in the divisor; when the figures on the left hand of this separation will be the quotient, and those cut off will be the remainder: thus.

```
1|00) 487|56 (            1|0000) 92|7563(
      -------                     --------
Quot. 487|56 Rem.         Quot. 92|7563 Rem.
```

For neither in multiplication nor division, does the integer 1 make any change in the number to be multiplied or divided.

Division, like multiplication, may be proved by casting out the nines, as in the following example.

```
                548)129414(236        Quot. 236
                    1096··            Div.  548
                    ----                    ----
                    1981                    1888
     3              1644                    944
  \     /           ----                   1180
8    X    2          3874                 ------
  /     \            3288                 129328
     3               ----                Rem. 86
                     ··86                 ------
                                   Divid. 129414
```

Cast out the nines of the divisor, and place the surplus 8 on the left of the cross: do the same with the quotient, placing the surplus on the right: multiply these two numbers together, and adding what is above 9, to the figure in the remainder, place this last surplus on the top of the cross: then throwing out the nines of the dividend, the surplus to be placed in the bottom, ought to be the same with that in the top. The most accurate proof however, is to multiply the quotient by the divisor, when the product together with the remainder of the division, should be equal to the dividend.

Compound Division.

By this operation we divide numbers composed of different denominations, in which case the highest denomination is divided like any other integers. If there be any remainder, it is multiplied by the number of units in the next lower denomination, composing an integer of the higher denomination, adding to the product the figures of this lower denomination, given in the dividend. This last sum is then divided by the original divisor, and the remainder is proceeded with as the former, until the whole dividend be exhausted: for instance, were it required to divide £875 .. 14 .. 10 .. 3 among 8 persons, in equal shares, the work would be done in the following way.

```
    £    S.   D.   qrs.      £    S.   D.   qrs.
 8) 875  14   10   3        (109  09   04   1
    8                                       8
    —                        ——————————————————
    75                     £ 875  14   10   3
    72
    —
    3
    20
    —
 8) 74 (9
    72
    —
    2
    12
    —
 8) 34 (4
    32
    —
    2
    4
    —
 8) 11 (1
    8
    —
    3
```

The sum of pounds divided by 8 quotes £109, and the remainder 3, which is also pounds, is brought into shillings, being multitplied by 20, the shillings in a pound, taking in the 14s. of the original dividend, making in all 74s. which again divided by 8 will give 9s. for a quotient. The remainder 2 is next multiplied by 12, the pence in a shilling, taking down the 10d. in the dividend. This sum 34, divided by 8, quotes 4, and 2 pence remain, which, multiplied by 4, the farthings in a penny, and the three farthings of the dividend being added, will produce 11qrs. which also divided by 8 will give 1 farthing for a quotient, and 3 for a remainder. The whole quotient will therefore be £109 .. 9 .. 4 .. 1, the share of

each of the eight persons among whom the given sum was to be equally distributed.

To prove this operation the quotient, as in simple division, is to be multiplied by the divisor, adding the remainder; when the product ought to be equal to the dividend given; as is shown in this example.

Division of all denominations is performed in a similar manner, agreeably to the tables of measures and weights formerly given.

Of Reduction.

By Reduction we convert units of one denomination into those of another denomination, whether higher or lower. When we bring units or integers of a higher denomination into those of a lower, as pounds into shillings, pence, &c. tons into hundreds, quarters, pounds, ounces, &c. the operation is performed by multiplication, and is called *descending reduction*, as proceeding from a higher to a lower denomination: but when it is required to bring units of a lower denomination into those of a higher, as farthings, pence, &c. into shillings and pounds, or ounces, &c. into pounds, quarters, hundreds, &c. the operation is performed by division, and is called *ascending reduction*.

1st. *Reduction by Multiplication.*

In this part of arithmetic we multiply the sum or quantity given by the number of units of the next lower denomination, constituting one of the higher; adding to it the units of this lower denomination, if any be given, in the number required to be reduced: repeating this operation until the whole given sum or quantity be brought to the lowest denomination required.

Example. How many shillings, pence, and farthings, are in £365 .. 15 .. 10 .. 3?

£	S.	D.	qrs.
365	15	10	3
20			
7315	shillings		
12			
87790	pence		
4			
351163	farthings		

Writing down the given sum as in the margin, multiply the 365 pounds by 20, the shillings in a pound, taking down the 15s. of the given sum; by which the product will be 7315s. This sum is then multiplied by 12 the pence in a shilling, taking down the 10 pence of the given sum, making 87790 pence; which is lastly multiplied by 4, the farthings in a penny, and the 3 farthings of the given sum are taken in, giving the final result 351,163 farthings.

Should it be required to reduce 86 tons, 17 cwt. 3 qrs. 19 lb. to ounces, the reduction would be performed in this way.

```
   Tons    Cwt.   Qrs.   lb.
     86     17     3     19
     20
   ------
   1737  Hundreds
      4
   ------
   6951  Quarters
     28
   ------
  55608
 13902
 -------
 194647  Pounds
     16
 -------
1167882
194647
-------
3114352  Ounces.
```

Here the multipliers are 20 the hundreds in one ton, 4 the quarters in 1 hundred, 28 the pounds in 1 quarter, and 16 the ounces in 1 pound. The odd quantities given in the example, are severally added to the products of their respective denominations.

2nd. *Reduction by Division.*

This is done by dividing the given number of integers, by the number constituting an integer of the next higher denomination; observing that the remainder is always of the same nature with the dividend. Thus let us bring back to pence shillings and pounds, the number of farthings found in the preceding operation by multiplication,

```
   Farthings
4) 351163 (3
   ------
12) 87790 (10
   ------
2|0) 7315|5 (
   ------
£  365  15  10  3
```

Divide the farthings by 4 the number forming 1 penny; the quotient by 12 the pence in a shilling, and this last quotient by 20 the shillings in a pound, placing the remainder 3, 10, &c. as in the example. The result will be £365 .. 15 .. 10 .. 3, as given in the preceding question, of the accuracy of which this operation is a proof.

A similar proof of the correctness of the other foregoing example of reduction by multiplication, will be obtained by reversing the operation, and reducing the number of ounces there found, back to pounds, quarters, hundreds and tons, in this way,

```
         Ounces   28)      4)
     16) 3114352 (194647 (6951 (3
         16·····  168···  ─────
         ──       ───   2|0) 173|7 (
         151      ·266       ─────
         144       252     tons 86  17  3  19
         ──        ──
         ··74     ··144
           64      140
           ──      ──
          103      ··47
           96        28
           ──        ──
           ·75       19
            64
            ──
           112
           112
           ──
           ···
```

Dividing the ounces by 16 the ounces in one pound, we obtain 194,647 pounds, without any remainder: then dividing that quantity by 28 the pounds in a quarter, we have 6951 quarters and 19 pounds over: this quotient divided by 4, gives 1737 quarters, and 3 quarters over, and the hundreds divided by 20, give 86 tons, with 17 hundreds over. The given number of ounces will then be brought back to 86 tons, 17 hundreds, 3 quarters, and 19 pounds, as given in the former question.

In the practice of reduction it often happens, that both multiplication and division are necessary. This is the case when the given integers do not contain an entire number of the integers in question, as when it is required to convert pounds of money into guineas, or guineas into pounds: for example, if the pay of an officer in the army be a guinea per day, what will be the amount of his income for a year?

```
        Days
         365
          21
        ────
         365
        730
        ────
   2|0) 766|5 (
        ────
      £ 383 .. 5
```

Multiplying the days in a year 365, by the shillings in a guinea 21, and dividing the product 7665 shillings, by 20 those in a pound, we find the officer's yearly income to be £383 .. 5, equal to 365 pounds, and 365 shillings.

Again, how many guineas are in 500 marks, English?

Guinea	Mark
21s.	13s. 4d.
12	12
252 pence	160 pence
	500 marks

```
252) 80000 (317 guineas and 9s. 8d. over.
     756
     ·440
      252
      ----
      1880
      1764
      ----
  12) 116 pence
      ----
      9s. 8d.
```

The mark English containing 13s. 4d. or 160 pence, the 500 marks will contain 80,000 pence; which divided by 252 the pence in a guinea, will give for a quotient 317 guineas, with 9 shillings and 8 pence over.

Other questions commonly, but unnecessarily referred to the Rule of Three, or Proportion, may be solved by Compound Reduction. Thus, let it be required to calculate the worth of 12 dozen pairs of cotton stockings, when half a dozen pairs cost a guinea.

```
            6)
A guinea   21 shillings
           ----
1 pair      3s. 6d.
            12
            --
            42 pence
pairs      144
           ----
           168
          168
          42
          ----
     12) 6048 pence
         ----
     2|0) 50|4 shillings
          ----
        £ 25 .. 4.
```

Six pairs of stockings costing a guinea, one pair will cost 3s. 6d. or 42 pence, which multiplied by 144, or 12 dozens, will produce 6048 pence; and this sum reduced by division, will give £25 4, for the total price required.

Of Proportion.

The *proportion* or the *ratio* of two quantities, signifies the result obtained by comparing them together. If in comparing two

quantities, the object be to discover how much the one exceeds or falls short of the other, the result of this comparison, which is the difference between the quantities, is an expression of their *arithmetical ratio;* thus if we compare 12 with 8, their difference, 4, is the arithmetical ratio. Again, if in making this comparison, it be the object to discover how often one quantity contains or is contained in the other, the result will be the *geometrical ratio or proportion* between the two quantities: thus in comparing 12 with 4, in order to find how often 12 contains 4, the number 3 which expresses the number of times, represents the geometrical ratio or proportion between twelve and 4.

To represent these two modes of comparison of quantities, the numbers by which they are expressed are separated by one or more points: thus the arithmetical proportion between 12 and 8 would be written in this manner, 12 . 8.—this, however, is but seldom employed, as it may be mistaken for the expression of a decimal fraction. On the other hand, the geometrical proportion between two quantities, is expressed by two points placed the one over the other in this way 12 : 4. The two quantities are called the *terms* of the proportion, the first being the *antecedent*, and the last the *consequent*. To obtain the arithmetical ratio, subtract the less number from the greater; and to obtain the geometrical ratio, divide the greater by the less.

The arithmetical ratio continues the same when a quantity is *added to*, or *subtracted from* both the terms: thus, the arithmetical ratio of 12 to 8 is 4, and adding 6 to each term, we have 18 and 14, the difference between which is still 4, as before. The geometrical ratio undergoes no change when the two terms are *multiplied* or *divided* by the same sum: thus the geometrical ratio of 12 to 4 is 3; and multiplying both terms by 6, we have 72 and 24, the quotient of which is 3, as before.

When four sums or quantities are of such a nature, that the proportion or ratio between the two first, is the same with that between the two last, these four quantities are said to be *in proportion*, or *proportional*. Thus the four quantities, 5, 10, 8, 13, are arithmetical proportionals, the difference between 8 and 13, being the same with that between 5 and 10, that is 5; but the numbers 5, 10, 8, 16, are geometrical proportionals, because the 1st term is contained in the 2nd, just as often as the 3rd is contained in the 4th, that is twice. These last proportionals therefore are thus expressed 5 : 10 : : 8 : 16; or in words, 5 are 10, as 8 are to 16. Of these proportionals the 1st and 4th terms are called the *extremes*, and the 2nd and 3rd the *means*.

The fundamental property of numbers in *arithmetical* proportion is that the *sum* of the extremes is equal to the *sum* of the means: thus in 5, 10, 8, 13, the sum of the extremes 5 and 13, or 18, is equal to the sum of the means, 10 and 8, or 18.

The fundamental property of numbers in *geometrical* proportion is that the *product* of the extremes multiplied together is equal to the *product* of the means, thus in 5 : 10 : 8 : 16, 5 times 16 are 80, and 10 times 8 are 80.

When the two means of a ratio are the same, as in the arithmetical ratio, 5 are to 7 as 7 to 9, this sort of proportion is called a *continued ratio;* in which case the *sum* of the extremes is *double* the mean term: 5 and 9 are 14, equal to double 7: but when the *continued proportion* is geometrical, as 4 are to 8 as 8 to 16; then the *product* of the extremes is equal to the *square* of the mean term; for 4 times 16 are 64; equal to the square of 8, that is 8 times 8, or 64.

From this property of geometrical proportion it follows that, if we know the three first terms of a proportion, we can discover the 4th by multiplying the 2nd and 3rd terms into one another, and dividing the product by the 1st term; when the quotient will be the 4th term. Let there be given three quantities 3 : 9 : : 4; to find the fourth term. Multiply the 2nd and 3rd terms 9 and 4 together, and dividing the product 36 by the 1st term 3, the quotient 12 will be the 4th term required; for 12 contains 4 three times; that is just as often as 9 contains 3.

Hence also, by means of any three terms of a ratio, the 4th may be found: suppose the term wanted be one of the extremes, then multiply the two means together, and the product divided by the given extreme, will give the other for a quotient as in the preceding example. On the contrary, when the two extremes and one of the means are given, and the other mean is required, multiply the two extremes together, and divide the product by the given mean, and the quotient will be the mean required. For instance, let the numbers be 3 : 9 : :—: 12, where the two extremes and the 1st mean are given, and the 2nd mean is required. Multiply the two extremes 3 and 12, producing 36; and this product divided by the given mean 9, will give 4 for the mean required.

When four numbers are proportionals, they will still be so if transposed so that the extremes become the means, and the means the extremes: thus, as in the examples already given, if 3 be to 9, as 4 to twelve, by transposition 9 the mean will be to 3 the extreme, as 12 the extreme is to 4 the mean. The same thing will likewise happen, in whatever regular order the numbers are placed: As,

3 : 9 : : 4 : 12
3 : 4 : : 9 : 12
9 : 3 : : 12 : 4
9 : 12 : : 3 : 4
4 : 3 : : 12 : 9
4 : 12 : : 3 : 9
12 : 4 : : 9 : 3
12 : 9 : : 4 : 3

In all these various ways of stating the same proportionals, the product of the extremes multiplied together will be equal to the product of the means.

When two or more ratios or proportions are given, and the antecedents are multiplied together, as also the consequents together, the result is called a *compound ratio:* thus the proportion between 1 pound of money and penny is composed, 1st of the ratio between 1 pound and 1 shilling, and 2nd of the ratio between 1 shilling and 1 penny. The first ratio is 1 : 20, and the 2nd is 1 : 12; then

multiplying the two antecedents 1 by 1, we have 1, and multiplying the two consequents 20 by 12, we have a new proportion or compound ratio 1 : 240.

When the two ratios are equal, the result is a *double* or *duplicate* ratio; when the three ratios are equal, the result is a *triple*, or *triplicate* ratio; when the four ratios are equal, the result is a *quadruple* or *quadruplicate* ratio; &c. Thus, 1 : 2, and 1 : 2, give 1 : 4, or a duplicate; 1 : 2, 1 : 2, and 1 : 2, give 1 : 8, or triplicate ratio; and so on.

It was already stated as a fundamental principle of geometrical proportion, that the product of the extremes, is equal to the product of the means. The application of this principle is of the most extensive use in arithmetic, and other branches of mathematics; from which circumstance it is often called the *Golden Rule*: and as in employing it, there are always three things given, and a fourth is required, it is most commonly termed the *Rule of Three.* This rule is divided into two parts, called the *Direct* and the *Inverse.*

First. *Of the Rule of Three Direct.* This is so called because that of the four quantities concerned, two have always not only a relation to the two others, but are so intimately connected with them, that how often soever the first of the first set of numbers contains, or is contained in the first of the second set of numbers, just so often will the second of the first set contain or be contained in the second of the second set of numbers.

For example: If 75 yards of linen cost £18, what will be the price of 300 yards of the same linen?

```
Yards  £     Yards  £
 75 : 18 : : 300 : 72
      300
      ----  £
 75) 5400 (72
     525
     ----
      150
      150
      ----
      ...
```

Here three terms of the proportion are given, and the fourth is required, which shall bear to the 3rd term the same proportion that the 2nd does to the 1st. Write down the three given terms as here shown, distinguished by the proper points *(for this is not a matter of indifference)* to be thus read: as 75 yards are to 18 pounds, so are 300 yards to a fourth number, which will be so many pounds.

It was already observed that when one extreme and the two mean terms are given, if the means are multiplied together, and the product be divided by the given extreme, the quotient will be the other extreme. Let this be done here: multiply the mean term £18 by the other mean 300 yards; then divide the complex product 5400 by the given extreme 75 yards, and the quotient £72 will be the price of 300 yards.

Again, if I pay £170 for 6 hundred weight 1 quarter and 14 pounds of tea, how much should I have for £500?

```
£      Cwt. Qr.  lb       £    Cwt.
176  :  6    1    14  ::  500  :
        4
       ---
       25
       28
       ---
       200
        50
      -----
176  : 714  ::  500  :
       500
      -------28)
176) 357000 (2028 pounds
     352...  -----
     ..500   4)72 quarters 12 pounds
      352    --
     -----   18cwt. 0qrs. 12lb 6oz.
     1480
     1408
     -----
     ..72
       16
     -----
      432
      72
     -----
176)1152 (6
    1056
    -----
    ..96
```

In this example it is required to discover a quantity of tea which shall bear to £500, the same proportion that 6cwt. 1qr. 14lb bear to £176. Writing down the terms as here shown before proceeding to multiply the mean terms together, as one of them consists of quantities of different denominations, they must be all reduced to the lowest, bringing, as was shown in reduction, the hundreds and quarters to pounds weight in all, with the 14lb given, 714lb. We then obtain a new satement of the proportion: as £176 to 714 pounds of tea, so £500, to a fourth term which will be also pounds of tea, multiplying the middle term 714 by 500, and dividing the product by 176, we obtain a quotient of 2028lb, which reduced by division will give 18cwt. 0qr. 12lb, together with 6oz. drawn from the remainder of the division by 176, multiplied by 16 the ounces in a pound.

Again if £358 12 7 gain £83 13 4 in any given time, at a given rate of interest, what would £858 gain in the same time and at the same rate?

```
  £    Sh.   D.     £    Sh.   D.      £      £
 358   12    7  :  83    13    4 : : 858 :
  20               20                 20
----              ----              -----
7172              1673              17160
  12                12                 12
-----            -----             ------
86071    :       20080     : :     205920
                205920
              --------
              16473600
             41184000
            ----------  12)
   86071) 4134873600  (48040 (4
          344284 .... 2|0) 400|3 (
          ------      --------
           692033     £200  3  4  1
           688568
           ------
             346560
             344284
             ------
              22760
                  4
             ------
     86071)  91040 (1
             86071
             -----
              4969
```

In this case the 1st term consisting of pounds shillings and pence, the whole must be reduced to pence: and the same must be done with the 3rd term although it consist of pounds only; because these two terms must be of the same name and nature. The middle term consisting also of broken money must be likewise reduced to its lowest denomination. By these steps we obtain a new statement of the proportion; as 86071 pence to 20080 pence, so will be 205920 pence to the fourth proportional. As the 3rd term is greater than the 1st, and will consequently require a greater sum of interest, the middle term must be multiplied by the 3rd term and the product divided by the 1st. These operations will give for a quotient 48040 pence, or £200 3 4: and if the remainder of the division be multiplied by 4, the farthings in a penny, and the product be divided by the 1st term, an additional farthing will be obtained, as here stated.

Secondly, *The Rule of Three Inverse* differs from the *Direct Rule* in this particular, that of the four quantities, known and unknown, of the question, the two principal quantities are related to one another, or the one may contain the other, in an order directly contrary to that of the other two quantities connected with them.

In examining the statement of the question proposed, and placing the quantities or numbers so as to form a proportion, one of the principal quantities and its relative form the extremes, and the other principal quantity and its relative form the means. In such a position the principal quantities are said to be reciprocally proportional to their relative quantities: but this difference creates none in the mode of computation, as three quantities are still given, and a fourth is required.

Let it be required for example to find what sum of principal money will, in 156 days, gain as much interest as £630 would gain, at the same rate of interest in a year, Here it is evident that as the time in which the given sum of interest is shortened, the sum of principal must be augmented; and therefore that the sum required must bear the same proportion to the sum given, £630, as the number of days connected with this last sum, or 365 days, does to 156, the number of days connected with the sum required. Placing therefore the given sum £630 and its relative number of days, 365 or a year, as the two means, and the number of days relative to the sum required to be discovered, as the 1st extreme, we have this proportion.

```
Days     £      Days     £
156  :  630  : : 365  :
        365
       -----
        3150
       3780
      1890
     -------        £    Sh.  D
156) 229950   (1474   0    9
     156...
     -----
      739
      624
      ----
       1155
       1092
       ----
        ..630
          624
          ---
            6
           20
          ---
    156) 120 (0
          12
         ----
   156) 1440 (9
        1404
        ----
         ..36
```

Here in order to have a 4th term greater than the middle term, agreeably to the nature of the question, we multiply the middle term £630 by the greater number of days 365, and divide the product by the less number in the 1st term 156, when the quotient comes out to be £1474; and the remainder 6 reduced by multiplication gives no shillings but 9 pence; making £1474 0 9 the sum of principal which in 156 days would just gain as much, at any given rate of interest, as £630 would gain in a year.

Again, the garrison of a fortified town, consisting of 3560 men have a sufficient stock of provisions for 35 days: but in the prospect of a siege and blockade, which might perhaps last for 80 days, it becomes necessary to reduce the number of troops,

so that the same stock of provisions may hold out for that time. How many men must therefore be sent out of the place, in order that the remainder of the garrison may have their regular allowance of provisions?

The question here is how many men may be subsisted for 80 days, upon the provisions which would supply 3560 men for 35 days? In this case the 4th term to be discovered must be as much less than 3560, as the number of days 80 is greater than 35. Working therefore as in the margin, the 4th term will be 1557, the number of men who may be subsisted on the given stock, for 80 days: and this number subtracted from the whole the garrison 3560, will leave 2003 men, the number to be dismissed from the place.

```
Days   Men    Days   Men
 80  : 3560 : : 35
         35
      ------
      17800
     10680
      ------
8|0) 12460|0 (1
      ------
      1557 men
      3560 garrison
      ------
      2003 to be sent away.
```

Compound Proportion or Double Rule of Three.

This is an application of the foregoing rules, with this difference that the relation of the quantity sought, to the quantity given in the question, depends not only on the relation between two other given quantities, but on that which each of these given quantities bears to other two quantities also given in the question. When those last compound ratios or proportions are formed, the question is solved as in the simple rule of three.

Example. If 36 men dig 280 yards of a certain ditch in 22 days, how many yards of the same ditch ought 54 men to dig in 45 days?

Here are two sets of proportions: first if 36 men dig 280 yards in any given time, how much should 54 men dig in the same time? and secondly, if a certain number of labourers perform the discovered quantity of work in 22 days, how much ought to be done by the same labourers in 45 days?

Having stated, as in the margin, these two questions, the middle term of the second being vacant, to be filled up by the result of the first, they are both performed as in the single rule of three.

```
Men  Yards  Men  Yards
 36 : 280 : : 54 :
Days Yards  Days
 22 :------: : 45
-------------------
Men  Yards  Men
 36 : 280 : : 54 :
         54
       -----
```

If 36 men dig 280 yards in any time, 54 men, it appears, would dig 420 yards in the same time. Again if any number of men in 22 days dig the quantity just found, 420 yards in 45 days, the same men would dig 859 yards.

The same results will be obtained, and in general more speedily, by working as here shown. The proportions being stated as before, multiply the number of men in the 1st and 3rd terms by the number of days respectively connected with each; that is 36 by 22, and 54 by 45. Hence arises a new statement of one proportion in which the complex quantities 792 and 2430 are the 1st and 3rd terms, and the given yards 280 become as before the middle term. By this one operation the result turns out to be, as in the former way of working, 879 yards, and the remainder in both ways is of equal value; for as 2 the remainder in the first way is the 11th part of the divisor 22, so 72 the remainder in the last way is also the 11th part of the divisor 792.

```
        1120
       1400
       ------  Yards
   36) 15120  (420
        144
        ---
        ..72
          72
          --
          ..0

 Days  Yards   Days
  22 :  420 : : 45
         45
       ------
        2100
       1680
       ------ Yards
   22) 18900 (859
       176
       ----
        130
        110
       -----
         200
         198
        -----
        ..2) 22 (11
             22
             --
             ..

  Men   Yards   Men
  36 :  280 : : 54 :
 Days   Yards   Days
  22 : ------ : : 45
 ----------------------
  36 :  280 : :  54 :
  22             45
  --             --
  72            270
 72            216
 ---           ---
 792 : 280 : : 2430
       2430
       ----
     194400
     4860
     ------
792) 680400 (859 yards
     6336
```

```
·4680
 3960
 ————
 ·7200
  7128
  ————
  ··72) 792 (11
        792
        ———
        ···
```

Again, if £756 17 gain £258 16 in 6 years and 6 months, what principal sum will be sufficient to produce £496 13 8 in 9 years and 8 months?

```
  £      Sh.     £      Sh.        £     Sh.   D.
  258    16  :   756    17   : :   496   13    8
  Y.     M.                        Y.    M
  6      6   :   ——————————— : :   9     8

  258    16  :   756    17   : :   496   13    8
   20             20               20
  ————          ————              ————
 5176          15137              9933
   12                               12
  ————                           ——————
 62112     :     15137       : :  119204
                119204
                ——————
                 60548
                302740
               136233
               15137
               15137
               ——————————2|0)
     62112) 1804390948 (2905|0
            124224····  ———————
            ——————     £1452| 10  7
            ·562150
             559008
             ——————
             ··314294
               310560
               ——————
               ··37348
                    12
          62112) 448176 (7
                 434784
                 ——————
                 ·13392
```

```
 Y    M     £    Sh.    D    Y     M
 6    6 : 1452   10     7 : : 9    8 :
12          20               12
--         ----              --
78         29050             116
              12
          -------
   78 ;   348607 : : 116 :
              78
          -------
          2788856
         2440249
         -------  12)
  116)   27191346 (234406(0
         232·····  --------
         ---       2|0) 1953|4
          ·399          -------
           348          £976  14  0
          ----
           ·511
            464
           ----
            ·473
             464
            ----
             ··946
                928
               ----
                ·18
```

In this case the two given sums of interest must be the 1st and 3rd terms, and the given sum of principal, as being of the same name with the sum required, must be the middle term. Then as £496 13 8 must arise from a principal sum greater than that which produces £258 16 6 the middle term £756 7 must be multiplied by the greater extreme, and the product divided by the less extreme. This, when the three terms are all properly reduced on account of the odd shillings and pence, is done, and the result is £1452 10 7. Then the second question is stated, if £496 13 8, the given interest be produced from £1452 10 7 in 6 years and 6 months, (that is to say, months of the calendar or almanac) what principal would produce the same interest in 9 years and 8 months? The several terms being reduced to their lowest requisite denominations, it is evident that as the term in which the fixed sum of interest is to be produced is augmented a smaller sum of principal will be sufficient: consequently the middle term must be multiplied by the smallest period of time or 78 months, and the product divided by the greatest period or 116 months. The final result of the two operations is that £973 2 2 will be able to produce the given interest £496 13 8 in the given

time 9 years and 8 months, which was the point to be ascertained.

The same result will follow from the calculation, by one compound operation, as before shown.

```
                 Pence          Shillings          Pence
                 62112    :      15137     : :    119204
        months     116                                78
                --------                         --------
                372672                            953632
                62112                            834428
               62112                             --------
              ---------
              7204992    :      15137     : :    9297912
                              9297912
                             ---------
                             65085384
                            27893736
                            9297912
                          46489560
                          9297912
                          -------------2|0
    7204992) 140742493944 (1953|4
                          7204992....   ------
                          ---------     £976  14  0
                          68692573
                          64844928
                          ---------
                           .38476459
                            36024960
                           ---------
                            .24514994
                             21614976
                            ---------
                             .29000184
                              28819968
                             ---------
                               ..180216
                                     12
                               ---------
              7204992) 2162592 (0
```

Of Fellowship.

By this rule, also called *commerce*, and *distributive proportion*, we are enabled to divide among a number of partners the profits or loss arising from the employment of a common stock, in proportion to the share which each partner contributed to that stock. From the nature of proportional quantities it follows that in any number the sum of all the antecedents is to the sum of all the consequents, as each antecedent is to its consequent: or in other words that the sum of all the shares is to the sum of all the profit or loss,

as each individual share of the common stock is to the portion of profit or loss appertaining to such individual share.

Let it be supposed, for example, that it were required to divide 150 in the proportion to one another of 4, 5, and 6. The first share would be to the second in the proportion of 4 to 5; the second to the third as 5 to 6; and the first to the third as 4 to 6. But the sum of all the antecedents being to the sum of all the consequents in the proportion of each antecedent to its consequent, we will have the sum of 4, 5, and 6, or 15, to the sum of all the consequents 150, as each antecedent to its consequent; that is, as 4 to its consequent 40, as 5 to 50, and as 6 to 60. Now as the several antecedents taken together are 15, so the several consequents taken together amount to 150, the number or quantity required to be divided in the given proportions.

Example. Three merchants resolving to make a joint adventure in trade, Peter put in goods to the value of £480, James to the value of £640, and John to the value of £800. After the adventure was closed, on settling all accounts it was found that upon the whole concerns £240 had been gained. How much of this gain would fall to each partner in proportion to his share in the common stock?

	£
Peter's stock	480
James' do.	640
John's do.	800

Stock £ 1920 : £ 240 : : £ 480 :
480
―――
19200
960
―――
1920) 115200 (£ 60, or Peter's gain.
11520
―――
.....0

£ 1920 : £ 240 : : £ 640 :
640
―――
9600
1440
―――
1920) 153600 (£ 80, or James' gain.
15360
―――
.....0

£ 1920 : £ 240 : : £ 800 :
800
―――
1920) 192000 (£ 100, or John's gain.
19200
―――
....00

	£
Peter gained	60
James do.	80
John do.	100
Total gain	£ 240.

In this operation we are to discover each partner's share of the profits of the adventure, in proportion to his share of the common stock: we therefore add the three shares together, and state the proportions as the amount of the shares £1920, to the whole profits, so is each man's share of the stock, to his share of the common profits. By these three operations, we find that Peter who advanced £480, gained £60, James who advanced £640, gained £80, and John who advanced £800, gained £100. The amount of these three shares of the profit is £240, the whole profit supposed to accrue from the joint adventure.

But another variety in fellowship may often occur, namely, that when the partners not only put in unequal values of goods or money, but continue their concern in the enterprise for a longer or shorter time. In this case the calculations must be regulated by the conjunct ratio or proportion of the share of the common stock, and of the time that share was continued in the adventure. Thus A. B. C. and D. agreed to carry on business together for limited lengths of time. A. put in £756, and continued 18 months in trade: B. £928 for 15 months, C. £1256 for 12 months, and D. 1500 for 9 months. Upon a final adjustment of all matters between the partners, they found the clear profits upon the whole enterprise to be £640. Required each partner's proportion of this sum conformably to his share of the common stock, and to the time for which his share was employed in the business.

```
           £              £              £              £
        A. 756         B. 928         C 1256         D. 1500
     months 18      months 15      months 12       months 9
        ------         ------         ------          ------
A.     13608          13920          15072           13500
B.     13920
C.     15072
D.     13500
      -------
       56100
                 £
       56100 : 640 : : 13608 :
               13608
              -------
              544320
             81648
            --------    £     S.    D.
  56100)  8709120  (155   4     10½   A's. profit.
          56100··
          -------
          309912
          280500
          -------
          ·294120
           280500                   £    S.    D.
           -------           A.    155   04    10½
```

```
        ·13620
            20
        ——————
56100) 272400 (4
       224400
       ——————
        ·48000
            12
       ——————
56100) 576000 (10
        56100·
       ——————
        ·15000
             4
       ——————
56100)  60000 (1
        56100
        ——————
         ·3900
```

B.	158	16	00½
C.	171	18	10½
D.	154	00	02½
	639	19	11¾
Remainder			¼
£	640	00	00

Here we have a double series of proportions, the one of the several shares contributed by the partners, to form the common stock in trade, the other of the several periods of time for which each share was so employed. Hence as A. employed his share for 18 months, his share of the profits would be the same as if he had contributed 18 times the stock for 1 month. B's. share was in trade 15 months, it would therefore be of the same value as 15 times that stock for 1 month; and so with the others. It becomes necessary therefore, to multiply each share by the months for which it remained in the trade, and by that step we obtain the following compound quantities, for A. 13,608, for B. 13,920, for C. 15,072, and for D. 13,500. These added together give 56,100, as the amount of the whole stock and time, for the first term of the several proportions: the second is the gain accruing from the whole enterprise £640: the third term is each partner's compound share of stock and time. According to this statement A's. share of the profits, as shown above, will be £155 .. 4 .. 10¼: the other operations (not inserted here, but which the student will readily perform for his own satisfaction) will give for B. £158 .. 16 .. 0½, for C. £171 .. 18 .. 10½, and for D. £154 .. 0 .. 2½. These several profits added together, amount to £639 .. 19 .. 11¾, to which if we add the value of the remainders in the four operations, when put together and divided by 56,100, the quotient 1 farthing will just make up the given profit £640.

Practice.

The foregoing rules comprise the usual system of arithmetic, applicable to all sorts of calculation. It is always however, desirable to be able to abridge labour in computations, particularly in the bustle of actual business, both to save time and to lessen

the occasions and chances of mistake. Sundry methods have therefore been devised, for shortening the process of calculating the price of a number of yards, pounds, bushels, &c. when the value of one of these quantities or measures is given, as also in computing the interest of money.

1st. *Of calculating prices.*

When the price of the unit of any number of articles is given at a pound, a shilling, a penny, or a farthing; then the total price will be so many pounds, shillings, pence, or farthings as there are units in the given number: hence 25 quartern loaves at 1 shilling each, will cost 25 shillings £1 .. 5.

Again, when the price of the unit is any even or aliquot part of a pound, a shilling, &c. the number of articles given must be divided by the number of such aliquot parts forming an integer, and the quotient will give the price required. Thus the price of 100 pairs of stockings at 5 shillings each pair, will be £25, because 5s. being the 4th part of 20s. or £1, 4 pairs will be worth £1; consequently there will be as many pounds as there are fours in 100; that is, 25.

When the rate or price of the unit is not an aliquot part of a pound, &c. but is composed of two or more such parts, the number of units is to be divided by each of these aliquot parts, and the sum of the quotients will be the price of the whole number given: thus the price of 24 pounds weight of sugar, at 9 pence per pound, will be found to be 18 shillings; in this way: as 9 pence is no aliquot part of a shilling, let it be divided into two parts, as 6 pence and 3 pence; then as 6 pence are the half, and 3 pence the fourth part of a shilling, by taking the half and the fourth part of the number of pounds of sugar, that is 12 and 6 together, equal to 18, we have the number of shillings for the required price of 24 pounds of sugar.

If the given price or rate be equal to the difference of rates easily computed, they may be separately calculated, and the less subtracted from the greater. If, for instance, the price were 11 pence, we may calculate the amount at 1 shilling and also at one penny, which last subtracted from the former will leave the amount at 11 pence.

And if the rate be a compound number, we may calculate first for one of the component parts, and multiply the amount by the other component part: that is, if the price were 54 shillings, we could multiply the number of articles by 9, and the product by 6, to have an amount corresponding to 54.

In performing computations in this way the following tables of the aliquot parts of a shilling and a pound will be useful.

Table of the aliquot parts of a Shilling.

Pence			
1	is	1 twelfth	part of a shilling.
2		1 sixth	
3		1 fourth	
4		1 third	
6		1 half	

5	is the sum of	4d. and 1d. or 3d. and 2d.
7		6d. and 1d. or 4d. and 3d.
8		6d. and 2d. or twice 4d.
9		6d. and 3d. or thrice 3d.
10		6d. and 4d.
11		6d. 3d. and 2d.

Table of the aliquot parts of a Pound.

S.	D.			
1		is	1 twentieth	part of a pound.
1	3		1 sixteenth	
1	4		1 fifteenth	
1	8		1 twelfth	
2	0		1 tenth	
2	6		1 eighth	
3	4		1 sixth	
4	0		1 fifth	
5	0		1 fourth	
6	8		1 third	
10	0		1 half	

1	6	is the sum of	1 shilling and its half
3	0		2s. and 1s.
6	0		5s. and 1s.
7	0		5s. and 2s. or 4s. and 3s.
8	0		5s. and 3s. or double 4s.
9	0		5s. and 4s.
11	0		10s. and 1s.
12	0		10s. and 2s. or triple 4s.
13	0		double 4s. and 5s.
14	0		10s. and 4s.
15	0		10s. and 5s. or triple 5s.
16	0		10s. 5s. and 1s. or 4 times 4s.
17	0		thrice 5s. and 2s.
18	0		10s. and twice 4s.
19	0		thrice 5s. and 4s.

Example. Required the value of 8 pieces of ribbon, each containing 22 yards at 9½d. per yard.

Here the price of the unit or yard being no aliquot or even part of a shilling, we must take such parts as, added together, will make up the given price. Thus twice 4d. and 1½d. will make up 9½d. By the table we see 4d. to be ⅓ part of a shilling; it is therefore twice set down as

D.	S.	Pieces	
		8	
4 is	⅓	22	
4	⅓	—	
1½	⅛	176	yards
—		—	
9½		58	8
		58	8
		22	0
	2|0)	13|9	4
		£ 6 .. 19 .. 4.	

above; and 1½d. is ⅛ part of a shilling. Multiplying the number of pieces of ribbon by the yards in each piece, we have 176 yards. This quantity we divide by 3, that is we take ⅓ part of it, because 4d. is ⅓ of a shilling. The quotient is 58, and the remainder 2 is ⅔ of a shilling, or twice 4d.; we therefore set down 8 in the column for pence. The same thing is done for the second 4d.: and the yards are next divided by 8, corresponding to 1½d. which give for a quotient 22 shillings, without any remainder. These three sums added together amount to 139s. 4d. or £6 .. 19 .. 4, the required value of the given articles.

Again, what is the value of 426 yards of coarse linen at 1s. 11½d. per yard?

D.		yards	
		426	
6	½	213	0
4	⅓	142	0
1½	⅛	53	3
11½		83|4	3
		£ 41 .. 14 .. 3.	

In this case as the price of one yard is 1s. 11½d. we consider each yard to be worth one shilling independently of the pence, and therefore reckon in the number of yards, as composing so many shillings, whereas in the former example the number of yards was excluded. For the pence in the price we take any aliquot parts of a shilling making up 11½d. as here 6d. which is one half of a shilling, 4d. one third, and 1½d. one eighth part. The number of yards divided by 2, 3, and 8, will give the several quotients and the remainder above set down, which added to the 426 shillings in the upper line, produce £41 .. 14 .. 3, for the value of the linen.

The same may be found in this way.

As the price of one yard comes within a halfpenny of 2 shillings, compute the value of the whole quantity at 2s. and from that sum deduct 426 halfpence, or 17s. 9d.; the remainder will be £41..14..3, as before.

halfpence	yards
2) 426	426
	2
12) 213 pence	
	852 shill.
17..9	17..9
	83|4..3
	£ 41..14..3.

If one yard of muslin cost 9s. 9d. what will be the price of 46 pieces each containing 22½ yards?

Here multiplying the pieces 46 by the yards in one piece, we have in all 1035 yards. This multiplied by the 9 shillings is the price together with the value of the odd pence, will give in all £504..11..3. But an equal result may be obtained by employing the fractions or aliquot parts of a pound, instead of those of a shilling, in the following way.

D.		Pieces		
6	$\frac{1}{2}$	46		
3	$\frac{1}{4}$	$22\frac{1}{2}$		
9		1012		
		23		
		1035	yards	
		9	shillings	
		9315		
		517	6	
		258	9	
		1009|1	3	
		£ 504..11..3.		

Here the yards are divided by those parts of a pound which added together make up 9s. 9d. the given price of 1 yard, and the answer is the same as before.

S.	D.		yards		
4		$\frac{1}{5}$	1035		
2	6	$\frac{1}{8}$	207	0	0
2		$\frac{1}{10}$	129	7	6
1	3	$\frac{1}{16}$	103	10	0
9	9.		64	13	9
			£ 504..11..3.		

Required the worth of 15 pieces of broad cloth, averaging $24\frac{1}{2}$ yards each piece, at £1..8..9 per yard.

The total yards in these pieces are $367\frac{1}{2}$ and as each yard costs £1, besides smaller money, we consider each yard as a pound. To this sum we add the several sums corresponding to the aliquot parts 5s. 2s. 6d. and 1s. 3d. giving (together with 14s. $4\frac{1}{2}$d. for half a yard) £528..5..$7\frac{1}{2}$ for the price of the cloth.

S.	D.		Pieces		
5		$\frac{1}{4}$	15		
2	6	$\frac{1}{8}$	$24\frac{1}{2}$		
1	3	$\frac{1}{16}$	$367\frac{1}{2}$	yards	
			91	15	
8	9.		45	17	6
			22	18	9
			$\frac{1}{2}$ yard	14	$4\frac{1}{2}$
			£ 528..05..$7\frac{1}{2}$.		

yard
£ 1..8..9
S. 14..$4\frac{1}{2}$

The same answer may be obtained by employing the aliquot parts of a shilling, in this way.

Multiplying the yards by 28, the shillings in the price of one yard; taking out of the yards the aliquot parts corresponding to 6d. or 3d. and adding the price of the half yard; the total comes to be the same as in the former operation.

There is still another way to perform the same calculation, by means of reduction, as follows.

D				
6	$\frac{1}{2}$	$367\frac{1}{2}$ yards		
3	$\frac{1}{4}$	28 shillings		
9		2936		
		734		
		10276		
		183	6	
		91	9	
		14	$4\frac{1}{2}$	$\frac{1}{2}$ yard
		1056|5	$7\frac{1}{2}$	
		£528 5	$7\frac{1}{2}$	

Reducing the price of one yard to pence, multiply it by the number of yards, to which product, adding, the value of the half yard in pence, and bringing the sum by reduction both to pounds &c. we have the same result as before.

Upon this it may be observed that, in general where the calculation of prices &c. is a little complicated and tedious, time will be saved, and fewer chances of error will be encountered, by employing reduction, as here shown, than by the common rules of practice.

Sh.	D	
28	9	
12		
345 pence		
$367\frac{1}{2}$ yards		
2415		
2070		
1035		
126615		
$172\frac{1}{2}$		$\frac{1}{2}$ yard
12) $126787\frac{1}{2}$	($7\frac{1}{2}$	
1056|5		
£528 5 $7\frac{1}{2}$		

2nd. *Deductions on weight, &c.*

Goods or merchandise, weighed in the box, cask, or other package, are said to be in their *gross* weight; and proper allowances being made for these packages, the remainder is called the *neat*, or as it is commonly termed the *nett* weight. This abatement or allowance is called *tare*, and is usually calculated at the rate of so much on the hundred weight of the gross quantity. *Tret* is another allowance granted on certain kinds of goods that are liable to lose by keeping a part of their substance, and consequently of their bulk or weight; in order that they may still be complete when afterwards re-sold. *Draught* is also an allowance given, to turn

the scale of the balance in favour of the purchaser. All these allowances are computed in the following way.

Required the nett weight of 35cwt. 3qrs. and 18lb gross, allowance for tare being given at the rate of 16lb per cwt.

	Cwt.	Qrs.	lb	Oz.	
7)	35	3	18	0	gross
	5	0	14	9	tare
Cwt.	30	3	03	7	nett

The tare being 16lb on the cwt. that is one seventh part of the gross weight, we have only to divide the given quantity by 7 to obtain for tare 5cwt. 0qrs. 14lb 9oz. which deducted from the gross weight will leave 30cwt. 3qrs. 3lb 7oz. nett.

The tret allowed upon this nett weight, at the rate of 4lb to the cwt. is thus computed.

	Cwt.	Qrs.	lb	Os.	C.	Q.	lb	Os.	
112	30	3	03	07					
4				4					
116)	123	0	13	12	(1	0	06	14	tret to be allowed
	116				30	3	03	07	nett weight
	..7			Cwt.	29	2	24	09	Real weight when the goods are resold.
	4								
116)	28 (0								
	28								
	224								
	56								
116)	797 (6								
	696								
	101								
	16								
116)	1628 (14								
	116								
	468								
	464								
	..4								

Having deducted from the gross weight of the goods the tare before found, for the packages, the seller grants an allowance of 4lb on every 112lb to enable the buyer to make out the same quantity when he sells again. The nett weight is therefore multiplied by 4 the tret allowed, and the 112lb or the hundred weight, increased by 4, to 116lb becomes the common divisor: for this last quantity bears to its tret the same proportion that the whole nett goods bear to their trett.

3rd. *Of Interest.*

By this term is understood the allowance made, by the borrower of a sum of money, to the lender, for the use of that money; and it is computed at the rate of so much on every hundred pounds, for a whole year. By the laws of this country the highest rate that can be demanded or paid for the use of money, or the legal interest, is limited to £5 per £100 annually, and proportionably for any other sum, and for any other period. In the British West India colonies the legal interest is £6 in the £100. Interest may be calculated by simple or compound proportion, in the way before shown: but for practise shorter methods are convenient. One is to find what part of £100, the rate of interest is, and take the same part of the given sum of money, of which the interest is required. The common way of expressing the rate of interest is by the latin words *per centum per annum*, signifying *by the hundred and by the year*, or usually shortened into *per cent.* Thus in computing the interest of £500 at £5 *per centum per annum* or 5 per cent. as 5 is the 20th part of 100, we have only to take the 20th part of the given principal, that is of £500, or £25, which will be the interest for one year on that sum at 5 per cent. Had the rate been 4 per cent. we would have taken the 25th part of the principal, because 4 is the 25th part of 100.

Example. Required the interest of £775 for one year, at 4 and at 5 per cent.

```
          £
4  1/25) 775 (0
         ----
        £31..0

5  1/20) 77|5 (
         ----
        £38..15
```

In the first case dividing 100 by 4 we have 25 for a quotient, which, becoming the divisor of the given principal, gives £31 for one year's interest at 4 per cent. In the second case 5 being the 20th part of 100, we divide the principal by 20, and the quotient is £38..15 for a year's interest. The same thing may be done by the common rule of three, saying as £100 to £4, or £5, so £775 to another quantity which will be the respective sums of interest: but on account of the number of inefficient figures 0 and 1, the operation would be unnecessarily tedious: it is therefore laid aside in practice, and the above short methods are preferred, even where the principal consists of broken sums of money.

At 4½ per cent. what is the interest of £875..13..4 for 3 calendar months, or a quarter of a year?

This rate of interest 4½, or £4..10 per cent. is no aliquot part of £100; we must therefore proceed by proportion, thus,

```
 £        £  Sh.        £   Sh.  D.
100  :    4  10   : :  875  13   4
 20      20             20
----     --            ----
```

2000   90   17513
12   12

24000 : 90 : : 219160
90

2|0)
24|000) 19724|400 (82|1..10
192..
..52   £41..1..10 for 1 year.
48   £10..5..$5\frac{1}{2}$ for $\frac{1}{4}$ year.
.44
24
204
.12
24|0) 244|8 (10
24..
..48
4
240) 192 (0

Here one of the extremes containing shillings and pence, both must be reduced to pence, and the middle term £4..10 is brought down to shillings. Working according to the rule of proportion, we have £41..1..10 for one year's interest of the given sum of principal, a fourth part of which is the required interest for a quarter of a year or 3 months.

What will be the amount of interest due upon £7693..18..6 at 5 per cent. for the first 6 months of the year 1814 which is not leap year?

	Days
January	31
February	28
March	31
April	30
May	31
June	30
Days	181

£   £   Sh.   D.
5 is $\frac{1}{20}$) 7693   18   6 (
384   13   11 interest for 1 year.
20
7693
12
92327
181 days in first 6 months.
92327
738616
92327
12)
Days in a year 365) 16711187 (45784 (4

```
1460....      ------
------        381|5
 2111         ------
 1825         £190..15..4 interest required.
 ------
 ·2861
  2555
  ------
   3068
   2920
   ------
   ·1487
    1460
    ----
    ··17
```

Here 5 being the 20th part of 100, we divide the given principal by 20, to obtain the interest for a whole year £384..13..11. But as the given months contain only 181 days we multiply this interest, reduced to pence, by that number, and divide the product by 365 the days in a common year, by which step we have a number of pence equal to £190..15..4 for the interest for the given period.

A person holds a bill for £500, due on the 1st of August: but wishing to have cash for it on the 25th of April, what discount must he allow for ready money at that time, at the rate of 5 per cent?

```
           £                                   April 6 days
  5 1/20) 500                                  May   31
          ---                                  June  30
           25                                  July  31
           98                                        --
          ---                                        98 days
          200
          225
          ---   £  Sh.  D  Qrs.
  365)   2450 (6  14   3  3 discount
         2190
         ----
          260
           20                            Bill £500..00..0..0
         ----                        Discount    6..14..3..3
  365)   5200 (14                            ---------------
          365                         Value £493..05..8..1
         ----
         1550          360
         1460            4
         ----          ----
         ··90        ) 1440 (3
           12          1095
         ----          ----
  365)   1080 (2        345
          720
         ----
          360
```

Of Fractions.

A *fraction* in arithmetic signifies any quantity less than a given integer: thus one quarter or one fourth part is a fraction of a whole quantity, being, as the name imports, a part broken off from a whole. To form a distinct notion of fractions, we are to suppose a whole unit to consist of a certain number of equal parts, of which parts one or more being taken, and one or more left, both the parts taken and the parts left behind are all equally fractions, that is broken parts of that whole unit. Thus if we divide a pound of tea into 16 equal parts or ounces, each ounce or any number of ounces less than 16, will be a fraction of a pound. One ounce will then be called one sixteenth part, eight ounces will be eight sixteenth parts or one half of a pound.

Different ways are adopted to express fractions: one is to give them particular names and then to employ them as whole quantities; thus 10 ounces may, with regard to the pound as the integer, be considered as ten sixteenths of a pound; but with regard to the ounce itself as an integer, they are ten integral quantities. In the same way 15 shillings are 15 twentieths of a pound, if we refer to the pound as the integer, or unit, but they are 15 integers in the view of the shilling being the unit.

The other way of expressing a fraction (that is what is called a *vulgar* fraction) is to write under a small line the number of parts into which any unit is divided, and above the line the number of those parts included in the given fraction. Thus 15 shillings, considered as a fraction of a pound consisting of 20 shillings, would be expressed in this way $\frac{15}{20}$ or fifteen twentieths of a pound; $\frac{1}{2}$ means that the integer is divided into two equal parts, of which one is employed in the fraction: $\frac{3}{4}$ of a penny signify three farthings, because the farthing (as its antient spelling indicated) is the fourth part of a penny. Hence in expressing sums of money, for seventeen shillings and nine pence farthing we write 17s. $9\frac{1}{4}$d.

In vulgar fractions the figure under the line is termed the *denominator*, as pointing out the number of parts into which the integer is divided, and the number above the line shows how many of those parts are included in the fraction, on which account it is called the *numerator*: thus $\frac{3}{4}$ express that the whole number is divided into 4 parts, of which 3 are contained in the fraction. Fractions of this sort are properly so called: but when on the other hand the numerator contains more parts than those into which the denominator is divided, then the fraction is improper: thus $\frac{5}{4}$ or five quarters is an improper expression instead of $1\frac{1}{4}$

Fractions of the same real value may be expressed in various ways, according to the number of parts into which the integer is divided: thus $\frac{1}{2}$, $\frac{2}{4}$, $\frac{3}{6}$, $\frac{5}{10}$, all alike express the half of any integer; for if we divide it into 2, 4, 6, or 10 equal parts, and take 1, 2, 3, or 5 of them respectively we take one half of the whole.

1st. In working with vulgar fractions the first thing necessary is to reduce a mixed number to an improper fraction; for example, to reduce $8\frac{3}{4}$ which is a mixed number partly integral, partly

fractional to an improper fraction, in which state we can work with it, we multiply the integral part 8 by the denominator 5 adding to the product the numerator 3, when the equivalent improper fraction will be $\frac{43}{5}$. The reason of this is, that seeing from the fractional part $\frac{3}{5}$ that the integer is divided into 5 equal parts, the integral part must of course contain 40 of those fifth parts, and with the addition of the numerator 3 the whole of the mixed number will contain forty-three of those fifth parts.

2nd. To reduce an improper fraction to its proper equivalent mixed number, we just reverse the foregoing operation. To reduce the improper fraction $\frac{43}{5}$ parts, we divide the numerator 43 by the denominator 5, when the quotient 8, together with the remainder 3, will again form the mixed number $8\frac{3}{5}$.

3rd. To reduce a fraction to its lowest term. It was already observed that the same real quantity may be expressed by various fractions, according to the number of parts into which it is divided: thus $\frac{224}{448}$, $\frac{18}{36}$, $\frac{2}{4}$, $\frac{1}{2}$ are all expressions of the same value, for each expresses that the fraction contains one half of the parts into which the integer is divided; and $\frac{1}{2}$ is the lowest term by which the half of any quantity can be expressed.

In finding this lowest term different methods are practised: one is to divide both numerator and denominator by the same number, as long as it can be done without a remainder, when the last quotients will be the lowest term: thus the fraction $\frac{875}{1125}$ may be divided several times in succession by 5, as $\frac{875}{1125} \mid \frac{175}{225} \mid \frac{35}{45} \mid \frac{7}{9}$, until we come to $\frac{7}{9}$ which can no longer be divided by any common divisor; we therefore consider $\frac{7}{9}$ as the lowest term of the given fraction $\frac{875}{1125}$.

These common divisors of a fraction are called its *common measures*, and in practice are equally found by trial: to discover this measure however methodically the rule is to divide the denominator by the numerator, and if any thing remain to divide the former divisor by it; repeating this operation as long as there shall be a remainder, when the last divisor will be the common measure of both parts of the fraction.

Example: required the common measure of the fraction $\frac{368}{456}$, or reduce it to its lowest term.

```
          368
          ---
     368) 456 (1
          368
          ---
          ·88) 368 (4
               352
               ---
               ·16) 88 (5
                    80
                    --
                    ·8) 16 (2
                        16
                        --
                        ··
```

Eight is therefore the common measure of this fraction $\frac{368}{456}$ and when both parts are divided by 8, making $\frac{46}{57}$ the fraction is brought to its lowest term; no number being able to divide them both any longer without remainders.

This operation rests upon the observation that whatever number measures two other numbers, it will also measure their sum and their difference, as well as any multiple or repetition of the same numbers; thus 8 which measures both parts of the fraction $\frac{368}{456}$, will also measure their sum 824, being contained in it 103 times, and their difference 88 in which 8 is contained 11 times.

4th. To reduce fractions having different denominators into others of the same value, but having a denominator common to all: for example, to reduce $\frac{3}{4}$ and $\frac{5}{6}$ to two equivalent fractions of the same name, that is in which the value of each shall be expressed, in the same parts of the integer to which they belong. Multiply each numerator successively by every denominator but its own, for a new numerator; and all the denominators together, for a common denominator. In the case above given, multiply the numerator 3 by the denominator 6 giving 18 for a new numerator in the place of 3; and the numerator 5 into the denominator 4, giving 20 for a new numerator in the place of 5, then multiplying the denominators 4 and 6 together we have 24 for a new denominator, common to both fractions which will stand thus $\frac{18}{24}$ and $\frac{20}{24}$, equivalent to $\frac{3}{4}$ and $\frac{5}{6}$.

Example: reduce $\frac{2}{3}$, $\frac{7}{15}$, $\frac{8}{9}$, and $\frac{33}{35}$ to fractions of the same nature, having a denominator common to them all; or give the value of each in proportional quantities, in the same parts of the integer or unit.

The given fractions are $\frac{2}{3}$, $\frac{7}{15}$, $\frac{8}{9}$, and $\frac{33}{35}$.

2	7	8	33	3
15	3	3	3	15
30	21	24	99	45
9	9	15	15	9
270	189	360	495	405
35	35	35	99	35
1350	945	1800	1485	2025
810	567	1080	9	1215
9450	6615	12600	13365	14175
14175	14175	14175	14175	

Here each numerator is multiplied in succession by all the denominators except its own: that is to say, 2 is multiplied successively by 15, 9, and 35; 7 by 3, 9, and 35, and so on: hence we have the numerators 9450, 6615, 12600, 13365, which with the common denominator 14175, formed by the successive multiplication of the four given denominators 3, 15, 9, and 35

together, produce fractions each equivalent to the corresponding fractions given, and, having this advantage, that they are all expressed in the same parts of the integer.

Addition of Vulgar Fractions.

Addition is performed by reducing the several given fractions to those having a common denominator, if they are not so at first, and then adding the numerators together for a numerator to the common denominator. Thus in the last example, were it required to add together the fractions there given, $\frac{2}{3}$, $\frac{7}{15}$, $\frac{8}{9}$, and $\frac{33}{35}$, when they are reduced to one denomination, the four new numerators must be added together, to form a new fraction with the common denominator, which will be $\frac{42030}{14175}$: but as this is an improper fraction, the numerator being greater than the denominator, it may be, as before shown, brought into its equivalent mixed number, as in the margin.

```
        9450
        6615
       12600
       13365
       -----
       42030
       -----
14175) 42030 (2 13680/14175
       28350
       -----
       13680
```

Subtraction of Vulgar Fractions.

This is performed by reducing the two fractions (if not so given) to a common denomination, and then taking the less numerator from the greater; the remainder becoming a new numerator to the former denominator Thus if from $\frac{5}{6}$ we take away $\frac{1}{2}$, that is $\frac{3}{6}$, the remainder will be $\frac{2}{6}$ or $\frac{1}{3}$.

Example from $\frac{785}{896}$ subtract $\frac{19}{45}$.

```
   785        19       896
    45       896        45
 -----     -----     -----
  3925      8064      4480
 3140        896     3586
 -----     -----     -----
 35325     17024     40340
 -----     -----
 40340     40340
   From    35325
   Subtract 17024
           -----
   Rem.    18301
           -----
           40340
```

When in mixed numbers the fractional parts, although given or made of a common denomination, are such that the fraction of the less number is greater than the fraction of the greater number, then as in subtraction of integers, an unit must be borrowed and divided into the same number of parts with those in the common denominator. For instance, if it be required to subtract 326 $\frac{8}{15}$ from 653 $\frac{5}{15}$ we borrow an integer or 15 fifteenths from the unit 3 of the greater number, which added to the 5 fifteenths in its fraction, make 20 fifteenths, from which subtracting the 8 in the less number, we have a remainder $\frac{12}{15}$ and one must be carried to the unit 6 in the less number, so that the whole remainder will be 326 $\frac{12}{15}$.

Multiplication of Vulgar Fractions.

This consists in multiplying the numerators of the two given fractions into each other, for a new numerator, and the denominators together, for a new denominator to that product. Thus in multiplying $\frac{5}{6}$ by $\frac{2}{3}$ we have for a product $\frac{10}{18}$ equal to $\frac{5}{9}$. This may be made evident by taking these fractions of a foot: for $\frac{1}{6}$ of a foot is 2 inches, therefore $\frac{5}{6}$ will be 10 inches; and $\frac{1}{3}$ of a foot being 4 inches, $\frac{2}{3}$ will be 8 inches. Then multiplying 10 inches by 8, the product is 80 square inches: but it was formerly noticed that the square inches in a foot are 144: if now we take the 9th part of that quantity the result is 16, and 5 times 16 are 80, which has just been found to correspond with the fraction $\frac{5}{9}$ of a foot, the product of $\frac{5}{6}$ multiplied by $\frac{2}{3}$.

From this example it will be understood why fractions multiplied together, produce quantities of less numerical value than the fractions themselves, and that even integers multiplied by fractions, give products of less apparent value than the integers. Thus 1 foot multiplied by $\frac{3}{4}$ of a foot, or 12 inches multiplied by 9 inches, will give only $\frac{3}{4}$ of a square foot, or 108 square inches. This discordancy however arises from the poverty of language, which compels us to employ the same term a *foot*, to express a certain measure of extent, of surface, and of solidity.

When integers or whole numbers are multiplied by integers, their value is apparently increased; when by the unit 1 their value remains unaltered; but when by a fraction, their value is diminished proportionably to the difference between the fraction and unity.

To multiply an integer by a fraction, you multiply it by the numerator, and divide the product by the denominator; and if there be any remainder it is annexed to the quotient as the numerator of a fraction, with the same denominator as that in the multiplier, as in the margin. This however is only an application of the rule already given; for the integers 764 may be represented as an improper fraction $\frac{764}{1}$ with 1 or unity for a denominator.

```
   764 7/8
     7
   ----
8) 5348 (
   ----
   668 4/8
```

To multiply an integer by a mixed number, first multiply it by the

integral part, and to the product add that obtained by the multiplication of the integer into the fractional part. For instance, in the annexed case, the integers 756 are first multiplied by the integer 8: then the same integers are multiplied by 5 the numerator of the fraction, and the product, divided by 6 the denominator, is added, to obtain the whole product 6678.

756	by	$8\frac{5}{6}$
8		
		756
6048		5
630		
		6|3780
6678		
		630

In multiplying a mixed number by a fraction, the fraction is first multiplied into the integral part, and then into the fractional: thus in multiplying 48 $\frac{2}{7}$ by $\frac{14}{15}$, 48 multiplied by $\frac{14}{15}$ will give 44 $\frac{12}{15}$, and $\frac{2}{7}$ by $\frac{14}{15}$ are $\frac{28}{105}$, which added to the $\frac{12}{15}$ or the equivalent fraction $\frac{84}{105}$, will make $\frac{112}{105}$ that is 1 $\frac{7}{105}$ to be added to the 44, making the whole product 45 $\frac{7}{105}$ or $\frac{1}{15}$.

To multiply two mixed numbers together, you must add the products of the two integral, and the two fractional parts, alternately multiplied into each other, when their sum will be the product required. For example, multiply 36 $\frac{2}{3}$ by 24 $\frac{2}{3}$. The integral parts are first multiplied together producing 864; then each integral part into the fractional part belonging to the other, giving in all 42; lastly the two fractional parts producing $\frac{6}{12}$ or $\frac{1}{2}$: and the sum of the whole is 906 $\frac{1}{2}$.

36	by	24	864
36	by	$\frac{2}{3}$	24
24	by	$\frac{3}{4}$	18
$\frac{2}{3}$	by	$\frac{3}{4}$	$0\frac{1}{2}$
			$906\frac{1}{2}$

This may be illustrated by common calculation. Taking equal quantities with the above in feet and inches. 36 $\frac{3}{4}$ will be 36ft. 9in. and 24 $\frac{2}{3}$ will be 24ft. 8in.: these quantities multiplied together, agreeably to the instructions given under the head of multiplication of integers, will produce 906 square feet, and 6 twelfth parts or 906$\frac{1}{2}$ feet.

Division of Vulgar Fractions.

Division is performed by cross multiplication: that is by multiplying the numerator of the dividend by the denominator of the divisor; for a numerator to the quotient, and the denominator of the dividend by the numerator of the divisor, for a denominator to the quotient. For instance, in dividing $\frac{5}{6}$ by $\frac{2}{3}$ we multiply 5 the numerator of the dividend, by 3 the denominator of the divisor, and obtain 15 for the numerator of the quotient. Again, we multiply 6 the denominator of the dividend, by 2 the numerator of the divisor, giving 12 for the denominator of the quotient, which will then be $\frac{15}{12}$, an improper fraction equal in value to 1 $\frac{3}{12}$ or 1 $\frac{1}{4}$.

In this operation our purpose being to discover how often 2 third parts of any quantity can be contained in 5 sixth parts of the same quantity, or to discover the difference between these quan-

tities, on the supposition that the greater contains the less but once; we must see that $\frac{2}{3}$ will be contained only half the number of times that $\frac{1}{3}$ would be contained in $\frac{5}{6}$. For this reason we divide the given dividend by 2, and multiply the quotient by 3, or in other words, we take 3 times the half of the dividend, to obtain the quotient required in the question. Thus in this example, bring the given dividend $\frac{5}{6}$ to another fraction of the same value, capable of division by 2, as for instance $\frac{10}{12}$: the half of this is $\frac{5}{12}$ and 3 times, the quotient will be $\frac{15}{12}$ or 1 $\frac{3}{12}$ that is 1 $\frac{1}{4}$ as before found. The truth of this will be evident if we suppose the given fractions to be parts of a foot, for instance, where the divisor $\frac{2}{3}$ of a foot will be 8 inches, and the dividend $\frac{5}{6}$ will be 10 inches. Here 8 is evidently contained in 10 once and 2 remain, or $\frac{2}{8}$ equal to $\frac{1}{4}$ consequently the quotient will be 1 $\frac{1}{4}$ as already found.

In dividing an integer by a fraction, or the contrary, the integer must assume a fractional form, by writing it as the numerator, with 1 for a denominator: thus 5 may be represented fractionally in this way $\frac{5}{1}$.

Mixed numbers, in the divisor or dividend, or in both, must be reduced, as formerly shown, to improper fractions; and then the division is performed in the usual way: thus,

$$
\begin{array}{l}
18\,\tfrac{2}{3})\ 166\,\tfrac{5}{6}\ (\\
\hline
56\ )\ 1001\ (3003 \\
\hline
\quad 6 \qquad 336)\ 3003\ (8\,\tfrac{315}{336} \\
\qquad\qquad\quad\ \ 2688 \\
\qquad\qquad\quad\ \ \overline{\ \ 315}
\end{array}
$$

Here the divisor 18 $\frac{2}{3}$ is reduced to the equivalent improper fraction $\frac{56}{3}$ and the dividend 166 $\frac{5}{6}$ to $\frac{1001}{6}$: multiplying these numbers alternately the products are $\frac{3003}{336}$ for the quotient equal to 8 $\frac{315}{336}$.

In keeping accounts of money, shillings and pence may be regarded as fractions of the higher denominations: pence as fractions of a shilling, or together with shillings as fractions of a pound. Hence the lower denominations of any sort may be considered as fractions of the higher, by placing the lower as the numerator of a fraction, of which the denominator is an unit of the higher denomination. Thus 8 pence becomes $\frac{8}{12}$ of a shilling, or $\frac{8}{12}$ of $\frac{1}{20}$ that is $\frac{8}{240}$ of a pound. The value of these fractions is found by reduction; multiplying the numerator by the integers in the higher denomination, and dividing the product by the given denominator: thus $\frac{9}{10}$ of a pound will be 18s. for 9 multiplied by 20, the shillings in a pound, and the product 180 divided by 10, the denominator, the quotient will be 18.

In arithmetical calculation it often happens that a quantity is expressed, as in the case just mentioned, as a fraction of a fraction

through several steps of progression. Thus the 8 pence are represented as $\frac{8}{12}$ of $\frac{1}{20}$ of a pound, for 1 penny is the 12th part of a shilling which is the 20th of a pound. To reduce all such fractions to one of the same value in parts of the highest denomination given, we multiply all the numerators successively together, for a numerator, and all the denominators together, for a denominator to the new fraction. Thus 12 ounces may be represented as $\frac{12}{16}$ of $\frac{1}{28}$ of $\frac{1}{4}$ of $\frac{1}{20}$ of a ton; or multiplying the numerator 12 by the others all units, we have still 12 for the numerator, and multiplying all the mumerators together, we obtain $\frac{16}{35840}$ of a ton as the expression for 16 ounces.

Decimal Fractions.

The nature and application of Vulgar Fractions being thus stated, it remains to give a brief explanation of Decimal Fractions. In money, weight, capacity, dimensions, or other measures of quantities, the unit or integer of any denomination has been divided, but without any regard to system, into various numbers of parts, at the option of different nations. Calculations founded on these arbitrary divisions of parts are frequently tedious, and of course subject to accidental errors. For this reason it has been agreed upon, among men of science, to suppose integers or single quantities of every kind to be divided into ten equal parts, called *decimal* or tenth parts, from the Latin word *decem*, signifying *ten*. Of these decimal parts each is again subdivided into other ten equal parts, called hundredth parts; these again into ten others called thousandth parts; and so on indefinitely.

Decimal parts and all their subdivisions are represented by the same numerical characters or cyphers as integers: but they are distinguished from integers by a point before them, or on the left hand: thus 8 without a point stands for 8 integers or whole units, but .8 with a point before it stands for a decimal fraction, to be read eight tenth parts of one integer. In the same way 88 will represent eighty-eight integers or units of any sort; whereas 8.8 signify only eight units and eight tenth parts of one unit; and .88 stand for no more than eighty-eight hundred the parts of one unit.

In decimal arithmetic, numeration is just the reverse of that of integral arithmetic. In this last the value of figures increases, in proportion as they are removed from the unit's place on the right hand to the left: but decimal figures decrease in value as they retire from the characteristic point on the left hand to the right. In integers the first figure on the right hand is an unit, and the others represent tens, hundreds, thousands, &c. as they recede to the left. In decimals on the contrary, the first figure after the separating point is a tenth, the next to the right hand a hundredth, the next a thousandth, and so on. Numeration of decimals is therefore performed as in the following table.

Distinguishing point	Tenth parts	Hundredth parts	Thousandth parts	Ten thousandth parts	Hundred thousandth do.	Millionth do.	Ten millionth do.	Hundred millionth do.	Billionth do.	
.	1	2	3	4	5	6	7	8	9	&c.

In this table on the left hand is the point, (similar to the full stop or period in language) serving to distinguish integers from decimals. The first figure .1 represents one tenth part of an unit or integer of whatever nature it may be; thus if the integer were a pound of money, 1 tenth part would stand for 2s. The second figure 2 in the place of hundredth parts represents two hundredths: and if to it we join the 1 in the place of tenths we have .12 to be read twelve hundredths. The third figure 3 signifies three thousandth parts, and joined to the foregoing figures, making .123, will represent one hundred and twenty-three thousandth parts: in the same way by taking in the 4 in the place of the ten thousandths, we have .1234 standing for one thousand two hundred and thirty-four ten thousandth parts of an unit. It is necessary to observe that, although the value of decimals diminishes in a tenfold proportion with respect to integers, according to their position respecting the characteristic point, yet in reading them their value relatively to themselves is reckoned from the left to the right, as in numeration of integers.

When a zero or nought is placed on the right of an integer, the value of the integer is increased tenfold; thus 8 signifies eight, but 80 is ten times eight or 80: zeroes or noughts on the left hand of an integer have no effect on its value, for 8, 08, 008, 0008, are all but eight. In reckoning decimals, the contrary takes place, for zeroes or noughts on the right hand of a figure have there no effect whatever on its value; but on the left hand, for every zero, the value of the subsequent figure is diminished to one tenth of its former value. Hence, .8 is eight tenths, .08 eight hundredths, .008 eight thousandths, .000008 eight millionths. Hence the figures representing the year 1814 will be of very different values, according to the position of the characteristic point.

1814. One thousand eight hundred and fourteen.
181.4 One hundred and eighty-one, and four tenths.
18.14 Eighteen, and fourteen hundredths.
1.814 One, and eight hundred and fourteen thousandths.
.1814 One thousand eight hundred and fourteen ten thousandths
.01814 One thousand 814 hundred thousandths.
.001814 One thousand 814 millionth parts, &c.

1st. *To reduce vulgar fractions to decimals.*

To the numerator annex a number of zeroes separated by the decimal point, and divide the whole by the denominator. For example let $\frac{56}{75}$ be brought to a decimal fraction of the same value.

```
75) 56.00000 (.74666
    52 5
    ------
     3 50
     3 00
     ------
       500
       450
       ---
        500
        450
        ---
         500
         450
         ---
          50
```

In this operation the quotient is brought into the form of a decimal fraction, by counting off from the last 6 (included) as many figures as there are noughts employed in the division, which here are five, and then placing before the 5th figure 7, the distinguishing or characteristic point, as is done in the example. The result of the operation is that .74666, or seventy four thousand six hundred and sixty-six hundred thousandth parts of any integer are equal to fifty-six seventy-fifth parts of the same. In other words, that if any given quantity be divided into seventy-five equal parts, and also into one hundred thousand equal parts, fifty-six of the former will be equal to seventy-four thousand six hundred and sixty-six of the latter.

In the foregoing division something is lost, because there is a remainder of 50: but although by taking down more noughts the division might be continued, and the quotient of course continually augmented, yet it would never arrive precisely at the full truth. For it will be seen from the last three divisions that the same remainder 50 will always be produced; and consequently that the rest of the quotient will consist of 6 repeated without end.

In reducing vulgar to decimal fractions the result obtains different names according to its nature: thus if the division end without a remainder, the quotient is said to be a *finite* or *terminate* decimal; when the division however far carried, still leaves a remainder, the decimal in the quotient is called *infinite* or *indeterminate;* when the same remainder is continually repeated, and the same figure continues to be repeated in the quotient, as in the example before given, the decimal becomes a *repeater;* if the repetition return not at every step, but after two, three, or more figures, the decimal is said to *circulate*, and the circulating figures are pointed out by an asterism, or other mark, at the beginning and end of the circle; while repeating decimals are distinguished by a dash or inclined line drawn across the repeating figure.

2nd. To reduce decimals of a lower to a higher denomination. Divide the given decimal, with a number of zeroes annexed when

necessary, by the integers in the higher denomination: when several denominations are given you begin with the lowest, adding its value to the next in order up to the highest.

For example, reduce 15 shillings 9 pence 3 farthings to the decimal fraction of a pound.

Sh.	D.	Qrs.
15	9	3
4) 3.00 (	12) 9.7500 (	20) 15.81250 (
.75	.8125	.790625

First we divide the 3 farthings, with some zeroes in the place of decimals, by 4, the farthings in a penny: the quotient .75 is then annexed in its proper place to the 9 pence, and the whole divided by 12, the pence in a shilling; the quotient .8125 is in the same way annexed to the 15 shillings, and the whole divided by 20, the shillings in a pound, will give .790625 as the decimal fraction of a pound, corresponding in value to 15sh. 9d. 3qrs.

3rd. To discover the value of any decimal fraction. Multiply the decimal by the integers in the next denomination inferior to that of the fraction, and cut off by the proper point, as many figures from the right hand of the product as the decimals in the multiplicand; then the figures on the left of the point will be integers of the lower denomination which, together with the decimal part, will be equal in value to the fraction given to be reduced. For instance, let the decimal fraction discovered in the last operatio nbe brought down to shillings, pence, and farthings.

	Tons		£
	.55875		.790625
	20		20
Cwt.	11.375	sh.	15.812500
	4		12
Qrs.	1.5	d.	9.750000
	28		4
lb.	14.	qrs.	3.000000

As zeroes on the right hand of decimals are of no value they are usually dropped: but their place must be reckoned in setting off the point, as is here done, in finding the value of .55875 of a ton.

Addition and *Subtraction* of decimals are performed like the same operations in integers, observing always to place the point of separation in the same vertical column, so that tens may stand under tens, hundreds under hundreds, &c.

76.285	5683.5
356.75	2898.76358
8.96852	
57.0074	Difference 2784.73642
528.64	
1027.65092 Sum	

In these examples the points being placed perpendicularly above and below each other, the figures on both sides obtain their proper position, and the number of decimal figures in the sum and the difference is equal to that in the longest line of the sums added and subtracted. The lower figures in the subtraction are supposed to be taken from tens, and one is carried on to the following figures on the left, without regarding the point of distinction.

Multiplication of decimals is performed in exactly the same way with that of integers: the only additional step is to cut off, by the point, from the right hand of the product, as many decimals as are equal to those in both the numbers multiplied.

Here the multiplication is carried on, without regarding the points; but in placing the point in the product, 7 figures are cut off from the right hand, equal to the 4 in the multiplicand and the 3 in the multiplier.

```
 968.7358
  46.133
 --------
 29062074
 29062074
 9687358
58124148
38749432
------------
44690.6886614
```

It sometimes will happen that the number of figures in the product is not equal to that of the two numbers multiplied, as in these examples.

```
   .0005689          .1102768
     .00036              .112
   --------          --------
      34134           2205536
     17067           1102768
-----------         1102768
.000000204804      ----------
                   .0123500016
```

When this occurs the number of figures in the multiplicand and multiplicator must be made up in the product, by adding zeroes on the left hand of the efficient figures, as here shown.

In multiplying decimals by 10, 100, 1000, &c. We have only to move the point from the left hand to the right, one place for every nought in the multiplier: thus,

```
 .56      .365      .0125489
  10       100          1000
----     ------   ----------
5.60    36.500    12.5489000
```

Division of decimals is done as in integers; and in ascertaining the value of the quotient we cut off from the right as many figures, as added to the decimals if any, in the divisor, will be equal to the decimals given or assumed in the dividend. When there are the same number of decimals in the divisor as in the dividend, then the quotient will consist entirely of integers: when there are more decimals in the divisor than in the dividend, zeroes must be added to the latter to make up the same number.

See these rules exemplified in the following cases.

```
8.56) 978.35846 (114.294
      856 .....
      ----
      122 3
       85 6
       ----
       3675
       3424
       ----
        2518
        1712
        ----
        .8064
         7704
         ----
         .3605
          3424
          ----
          .181
```

```
4.88) 999.99 (228.
      876 ..
      ----
      123 9
       87 6
       ----
       3639
       3504
       ----
        135
```

```
6.25753) 456.80000 (73.
         438 0271.
         ---------
         .1887299
          1877259
          -------
            10040
```

```
856) 6754.25 (7.89
     5992 ..
     ----
     .7622
      6848
      ----
      .7745
       7704
       ----
       ..41
```

Extraction of Roots.

The simple value of any number is called its *first* power, or the *root*, as from it spring all other values to which the same number can be carried. When this number is multiplied by itself, it is said to be *squared*, and the product is termed the *second* power, expressed by a small figure 2 over the number itself, thus 8^2. If this second power be again multiplied by the original number or root the product becomes the *cube* or *third* power expressed thus 8^3, which again multiplied by the root produces the *squared cube* power 8^4: this

multiplied by the root gives the *sursolid* or *fifth* power 8^5; which again multiplied by the original number will produce the *squared cube* or *sixth* power 8^6. In this way may any higher power of any given quantity be produced.

In the following table are contained the first, second, and third powers, of the nine digits.

1st power or root	1	2	3	4	5	6	7	8	9
2nd do. or square	1	4	9	16	25	36	49	64	81
3rd do. or cube	1	8	27	64	125	216	343	512	729

Here we see that 9 is the square, and 27 the cube of the root 3; 64 is the square, and 512 is the cube of 8; &c.

1st. *Extraction of the Square Root.*

Divide the given square number into periods of two figures each, beginning with the first on the right hand and counting to the left, if the square consist of integers: but if it consist of decimals begin at the left hand and mark off the figures in pairs to the right. For every period thus set off there will be a figure in the root.

Find what number when squared will be equal to or next under the first period on the left hand: write this number or root in the quotient, and its square under the same period, to be subtracted from it. To the remainder bring down both the figures of the next period of the given square: double the figure in the quotient, for a divisor to this new dividend, writing it as such, but leaving room for a figure or two in the place of units and tens. Then see how often this divisor is contained in the new dividend, (exclusive of the unit's place) and write the number of times in the quotient, as also in the void space left in the divisor, the whole of which is to be multiplied by the figure last placed in the quotient. This product subtracted from the last dividend will leave a remainder to which the next period of the given square is to be brought down, and the extraction of the root carried on as before.

Should it happen that the quotient doubled for a divisor cannot be taken out of the remainder, after the succeeding period is brought down to it, a nought or zero is to be written in the quotient and divisor, and another period is to be brought down from the given square, and the extraction continued.

When all the figures of the given square have been employed, and a remainder is still left, a period of two zeroes may be annexed to it, and the extraction still carried on: observing that the figures obtained in the root, after the zeroes are employed, will be all decimals and distinguished by the point.

Example. Required the root of the square 723775.5625.

Square number Root	
723775.5625 (850.75	850.75
64	850.75
165) 837	4253 75
825	59552 5
	4253750
17007) 127556	680600
119049	
	723775.5625
170145) 850725	
850725	
......	

Here is an example of the principal varieties occurring in the extraction of the square root. We begin by making a point or dot under 5 in the unit's place of the integral part of the square 723775. then passing over the second figure 7 we point the next figure 7; again passing the 3 we point the 2, which concludes the integral part. Then dividing the decimal part of the square .5625 into pairs, we place points under the 6 and the 5. By this we see that the root to be discovered will consist of three points, consequently of three figures of integers, and of two points or two figures in the decimal fraction. Next making the marks at each end of the square as in division, we inquire what number when squared or multiplied by itself, will be equal or nearest under the first period on the left hand of the square, which is 72. By the preceding table we see 64 to be the nearest square under 72, the root of which being 8 is written in the quotient, and the square 64 subtracted from 72 leaves 8. To this remainder we bring down the whole of the next period 37, and saying twice or double the root found 8 is 16, we write this as a divisor to the new square 837, leaving room for one or two figures in the place of units and tens: 16 will be found 5 times in 83; 5 is therefore written in the root after 8, and also in the divisor after 16, making altogether 165, which multiplied by 5 the root, will produce 825 to be subtracted as in the first step of the extraction. To the remainder 12 we bring down the next period of the original square 75, then doubling the whole root 85, we have 170 for a new divisor, with some places vacant. We now inquire how often 170 can be taken out of 127, (for the unit's place of the dividend is always excluded in this question) and finding it cannot be done at all, we write nought in the root making it 850, and also nought in the divisor now become 1700: then bringing down the next period 56 of the decimal part of the square, we inquire how often 1700 can be taken out of 12755: this being done 7 times, this figure is written in the root and in the divisor, which multiplied by 7 gives 119049. The difference between these numbers, with the last period 25 forms a new dividend, and the new divisor is double the whole root, or 17014, which is contained 5 times in the dividend 850725 without any

remainder. The extraction is therefore finished, and the root required is 850.75, two figures of decimals being set off from the right hand, because there are two periods of decimals in the given square numbers.

As a proof that the operation is correct we have only to square the root now found, that is, to multiply it by itself; when the product, as there was no remainder in the extraction, will be exactly equal to the square number originally given.

2nd. *Extraction of the Cube Root.*

This is performed as in the following example, where it is required to discover the root of the cubical quantity 176369715.712.

```
        Cubic number      Root
      ) 176369715.712 (560,7
         .  .  .  .

        125
        ----
   75)  513
        -----
        175616
        -----
 9408)  ...7537157
        ------------
        176369715712
        ------------
        ............
```

```
           5
           5
          --
  3 times 25
           5
         ---
         125
         ---
          56
          56
         ---
         336
        280
        ----
3 times 3136
          56
       -----
       18816
      15680
      ------
      175616
      ------
       560.8
       560.8
      4486 4
    336480
   28040
   ---------
   3144966 4
       560.8
   ---------
   25159731 2
 1886979840
157248320
------------
176360715.71 2
```

Having written down the given cubical quantity, distinguishing by the point the integers from the decimals, we begin to divide the integers into periods of three figures, by placing a point or dot under or over the unit's place 5, then passing over two figures (as in the square root one figure was passed over) we dot the fourth figure 9: again passing two figures, a dot is placed under the seventh figure 6. Thus we have three points, and consequently three figures for the root of the integer. As in the square root, the decimals were pointed off by couples, so in the cube root they are set off in periods of three figures each; and in this example the root will contain one place of decimals.

Having gone thus far, we inquire what number or root when cubed, or twice multiplied into itself will give a product the nearest under the first period of the integers 176. This will by the foregoing table appear to be 5, producing the cube 125, for the cube of 6 is 216. The root 5 is written in the quotient, and the cube 125 under the period 176. The difference between them is 51, to which bringing down not the whole period 369 as in the extraction of the square root, but only the first figure 3, we take for the divisor three times the square of the figure in the root which 5, or three times 25 that is 75. This is placed as a divisor, and the dividend is divided by it as in common division of integers. 75 being contained 6 times in 513, we write 6 in the quotient or root: then cubing the whole root 56, producing the cubical quantity 175616, this is written under the dividend 513, separated by a line, but in such a way that the cube stands directly under the first two periods of the original cube 176369, from which the new cube (and not from the dividend 513) is subtracted. To the remainder 753 we bring down 7 the first figure of the following period of the original cube; then taking thrice the square of the root already found, 56, that is thrice 3136 or 9408 for a divisor, we see that it cannot be taken out of 7537: we therefore write a zero in the root and take down the remainder of the period 15 together with the first figure 7 of the last period, and asking how often 9408 can be taken out of this new dividend, we see it may be done 8 times. This 8 is written in the root, and the whole of it being cubed, as in the example, the last product turns out to be exactly the same with the number given for extraction. The quotient 560.7 is therefore the cube root of that quantity. As in the decimal part of the given cube there was but one period or point, so we set off one figure from the right hand of the root for the decimal part of it.

Having thus gone through the most necessary branches of arithmetic, and this in the manner the least abstruse or embarrassing, and the best adapted to practise in ordinary life, it remains only to apprise the student, for his satisfaction and encouragement, that the rules laid down, and the examples given for his direction, are by no means either arbitrary or merely mechanical; but all founded on the nature of things and of numbers, and are susceptible of the most accurate and convincing demonstration.

CHAP. IV.

OF ALGEBRA.

ALGEBRA is a term brought from the Arabic language, signifying in general the art of comparing and equalizing quantities, and of resolving questions in arithmetic, where these operations are required. By algebra we discover a general form of expressing the results of all questions, including similar circumstances, relative to magnitude, quantity, or number; or in other words, by algebra we perform the several operations of addition and subtraction, of multiplication and division, employing not the common arithmetical cyphers, but other characters or symbols, of no real intrinsic value in themselves, but qualified to represent magnitudes, quantities, and numbers of every description. For example, let us suppose any number as 4 to be represented by the letter a, and 5 to be signified by b, and their sum 9 to be signified by c: then in algebraic language a and b added together will be equal to c, or thus $a+b=c$; that is in this case $4+5=9$. But the values of the arithmetical symbols 4, 5, and 9, having by long and unvaried usage obtained specific determinate values, they are not susceptible of any change; whereas the values affixed to the letters a, b, c, and the like, may be varied indefinitely, and operations performed by them still give correct results; thus a may stand for 12, b for 18, and c for their sum 30, then $a+b=c$, will represent $12+18=30$.

Although any letters of the alphabet may be employed, to represent quantities in algebraic operations, yet it has been found convenient, for distinction's sake, to use the letters in the beginning as a, b, c, d, e, &c. for quantities of which the values are given or known, and the letters in the end as v, x, y, z, for quantities neither given nor known, but which are required to be discovered. Thus in the

foregoing example the values of a and b being given, and their sum required, we would say $a+b=x$.

Algebraic quantities are connected by certain signs as (+) *plus* a latin term signifying *more*, denoting that the two quantities between which it is placed are to be added together: thus 4+5 are equal to 9. The sign (—) *minus* another latin term for *less*, denotes that one of the quantities between which this sign is placed is to be subtracted from the other: thus 9—5 equal to 4.

The sign ($\times$) between two quantities signifies that they are to be multiplied together: as 4×5 are 20, or $a \times b = z$. The product of two or more quantities multiplied into one another, is also represented by writing down the letters standing for them, close together as the letters in a word: thus the product of $a \times b$ is written ab, that of $a \times b \times c \times d$, is written $abcd$.

Division is expressed by writing the dividend above a small line and the divisor below it: thus $\frac{a}{b} = x$ will signify that the quantity represented be a, which suppose to be 24, if divided by the quantity represented by b or 6, will give for a quotient 4 or the value of x.

Equality of quantities in value is expressed by two small parallel lines (=): thus $a+b=c$.

[illegible]n arithmetical figure is placed before algebraic symbols, [illegible]he numeral coefficient, and shows how often the algebraic [illegible] to be repeated: thus 5 m will mean five times the [illegible]

[illegible]es consisting of the same characters are said to be *like*: so [illegible]nd 9 am are *like* quantities; but 5 am and 9 amm are *unlike* quantities. Quantities having the same signs before them, whether plus + or minus —, have *like* signs: but one having + and another — have *unlike* signs. Quantities with the sign plus + before them are *positive*, and those with minus — before them are *negative*. It is true that in the nature of things, a properly negative quantity cannot exist; because in common language the expression contains a contradiction of terms, as a negative quantity ought to be a quantity less than nothing: but in algebra the expression is used to describe such quantities as are to be deducted from others with which they are connected. Thus the amount of a person's estate may be considered as a *positive* quantity, and that of his debts as a *negative* quantity, which being deducted from the former will leave the true value of his property. When no sign stands before an algebraic quantity, it is always considered to be positive, and to have the sign plus +.

Addition in algreba is performed in three different ways.

1st. When the quantities are like, and have like signs, the rule is to add together the coefficients (counting a quantity having no coefficient as *one*) and to annex the common letter or letters, prefixing the common sign.

Examples.

+ 5 m	− 96 x z
+ 3 m	− 7 x z
+ m	− x z
+ 9 m	− 32 x z
+ 8 m	− 18 x z
+ 26 m	− 154 x z

2nd. When the quantities are *like*, but the signs *unlike*, all the positive quantities are added together, as are all the negative quantities; and the difference between these sums is the amount of the whole, having the sign belonging to the greatest sum.

Examples.

+ 8 *a*	+ 9 *n* − 8
− 2 *a*	− 6 *n* + 2
− 7 *a*	+ 24 *n* − 5
+ 9 *a*	− 4 *n* + 13
+ 17 *a* sum of +	+ 33 *n* + 15
− 9 *a* sum of −	− 10 *n* − 13
+ 8 *a* total	+ 23 *n* + 2

To understand these examples we may take the posit[illegible]ties as representing the several articles of a persons effects, and the negative quantities as his debts: in this case it is evident that, to know the true state of his affairs, we must deduct the debts from the effects, and the remainder will be his real property, equal to the complex amount of all the positive and negative quantities taken together. Thus in the first example we have $+8a$ and $+9a$ amounting to $+17a$ for the effects, and $-2a$ and $-7a$, amounting to $-9a$ for the debts, which last sum taken from the former will leave $+8a$ for the value of the remaining property.

3rd. When the quantities to be added are all unlike, they are written down in succession, with their respective signs and coefficients, in one line as in the following examples.

24 *a*	*c d* — *m*
— 9 *m*	3 *n o* + 54 *y z*
8 *n*	
x	$cd - m + 3no + 54yz.$
$24a - 9m + 8n + x.$	

Subtraction in algebra is performed by changing the sign of the quantity to be subtracted, and then adding the two quantities together as before shown.

Examples.

$$\begin{array}{r} 12\,b+8\,d \\ 7\,b-3\,d \\ \hline +5\,b+11d \end{array} \qquad \begin{array}{r} 9\,m-8\,n+32 \\ 5\,m-9\,n+48 \\ \hline 4\,m+\;\,n+16 \end{array}$$

In the first example where $7b-3d$ must be taken from $12b+8d$, if we change the sign of $7b$ which is $+$ into $-$, and then add the two quantities together, by the 2nd rule of addition, we shall have $+5b$: and in subtracting $-3d$ from $+8d$, if we change the $-$ into $+$, and add these quantities together, we shall have $+11d$. Had the question been to take only $7b$ from $12b+8d$, the remainder would evidently have been $5b+8d$: but as the sum to be subtracted is *less* than $7b$ by thrice the value of d, the remainder must be *greater* than it would have been, on the first supposition, by thrice the value of d; that is it must be $5b+11d$.

Multiplication in algebra is performed according to these rules. When the quantities to be multiplied have like signs, the sign of the product is $+$; and when they have unlike signs it is $-$. When the given quantities are simple, find the sign of the product by the above rule, to which annex the product of the coefficients, if any, and then all the letters, to make up the product required. Thus in the first example following, where the quantity $12cd$ is to be multiplied by $9m$, we muitiply the coefficients 12 and 9, giving 108 for the coefficient of the product, and write down the letters of both quantities beginning with the multiplicand, prefixing the sign $+$ because the factors have both the same signs.

$$\begin{array}{r} +12\,cd \\ +9\,m \\ \hline +108\,cdm \end{array} \qquad \begin{array}{r} +7\,b \\ -5\,d \\ \hline -35\,bd \end{array} \qquad \begin{array}{r} -8\,mnx \\ -5\,noz \\ \hline +40\,mnxnoz \end{array}$$

Again, when the factors are compound quantities, each term of the multiplicand is to be multiplied by each term of the multiplier, and the sum of these several products, collected according to the rules of addition, will be the general product required.

Examples.

$$\begin{array}{lr} & \text{1st.} \\ \text{multiply} & m+n \\ \text{by} & m+n \\ \hline & mm+mn\qquad \\ & mn+nn \\ \hline & mm+2\,mn+nn. \end{array} \qquad \begin{array}{l} \text{2nd.} \\ 8\,a+2\,c-4\,d \\ 5\,a \\ \hline 40\,a^2+10\,ac-20\,ad \end{array}$$

3rd.

$$\begin{array}{l} a+c-x+z \\ b-d+y \\ \hline ab+bc-bx+bz \\ \quad -ad-cd+dx-dz \\ \qquad\qquad ay+cy-xy+yz \\ \hline ab+bc-bx+bz-ad-cd+dx-dz+ay+cy-xy+yz. \end{array}$$

In the first of these examples where the quantity $m+n$ is squared or multiplied into itself, beginning (as is done in multiplying feet and inches by feet and inches in common arithmetic) at the left hand with the quantity m, this multiplied by the m of the multiplicand gives for a product mm; then n multiplied by m gives for a product mn. Again taking n for the multiplier and going over the multiplicand, we have for a product $mn+nn$, which is set down beginning under the multiplier n: and these two products added together give for the total product $mm+2\,mn+nn$. But when any number is multiplied by itself the product is a square, or the second power of that number; it is therefore usual instead of writing the quantity twice over, as mm or nn, to set down the root with the second third or other power marked over it; hence instead of $mm+2\,mn+nn$ we write m^2+mn+n^2.

In the second example $8a$ multiplied by $5a$ give $40a^2$, $5a$ by $2c$ give $10ac$; and as both these quantities have like signs, the signs of the product are $+$: again $5a$ by $4d$ give $20ad$, and the signs being unlike, that of the product is $-$; consequently the total product is $40a^2+10ac-20ad$.

In the 3rd example when the quantities in the multiplicator are incapable of combination with those in the multiplicand, being all represented by different characters, the sum of the three several multiplications must be written out in succession in one line, as was directed in speaking of addition.

These algebraic operations may be illustrated and confirmed by common arithmetic in this way. In the first example, for instance, let m represent 8, and n 6; then the operation will appear in this shape.

$$\begin{array}{lcr} 8+6 & & 8 \\ 8+6 & & +6 \\ \hline 64+48 & & 14 \\ \quad 48+36 & & \times 14 \\ \hline 64+96+36=196 & = & 196 \end{array}$$

Here the component parts of the given quantity, 8 and 6, are separately multiplied together, and the result is the sum of the products of 8 multiplied by 8, of twice 8 by 6, and of 6 by 6, in all 196, which is the product of 14, the sum of the two parts 8 and 6, multiplied by itself.

4th.

$$\begin{array}{llll}
a + m - x & & & \\
a - m + x & & & \\
\hline
a^2 + am - ax & & & \\
\quad - am - m^2 + mx & & & \\
\qquad\qquad ax + mx - x^2 & & & \\
\hline
a^2 \quad * \qquad * - m^2 + 2mx - x^2 & & &
\end{array}$$

In this example, in summing up the separate products we meet with $+am$ and $-am$, which being equal quantities with contrary signs destroy one another; that is, the one subtracted from the other, as is directed in addition, nothing will remain; a point therefore or asterisk is placed in the general products. In the same way $-ax$ and $+ax$ destroy one another, and their place in the product is filled by an asterisk; and the remaining terms are brought down in their order.

To illustrate this example by common arithmetic, let a represent 8, m 6, and x 4; then the operation will assume this appearance.

$$\begin{array}{lrr}
 & 64 & \\
 & -36 & \\
8 + 6 - 4 & \overline{} & \\
8 - 6 + 4 & 28 & \\
\hline
 & +48 & \\
64 + 48 - 32 & \overline{} & \\
\quad - 48 - 36 + 24 & 76 & 8 + 6 - 4 = 10 \\
\qquad\qquad 32 + 24 - 16 & -16 & 8 - 6 + 4 = 6 \\
\hline
64 \quad * \qquad * - 36 + 48 - 16 & = 60 & = \qquad 60
\end{array}$$

The products arising from the successive multiplications of a quantity by itself and by its several products are called its *powers*, of which the given quantity itself is the *root*: thus x is the root, and multiplied by itself the product, the square or second power will be xx, which again multiplied by the root will give the cube, or third power xxx; the fourth power will be $xxxx$, and so on. But as this mode of expression would soon become inconvenient and even exposed to great error, by the omission of a letter, it is the practice to express the power by a small figure set over the root; thus x squared is indicated by x^2, the cube by x^3, the fourth power by x^4, and so on to any extent. The figure thus set over the root is called the *exponent* or *index*; and by adding these exponents together the same result is expressed as if the root had been repeatedly multiplied: thus $a + a^2 = a^3$, and $a^4 + a^5 = a^9$.

Division of algebraic quantities is performed agreeably to the following rules; observing that when the signs of the divisor and dividend are like, that of the quotient is $+$, when unlike it is $-$.

1st. When the divisor is simple, that is, contains but one term, and appears in each term of the dividend, divide the coefficient of each term of the dividend by the coefficient of the divisor, and expunge or withdraw from each term the letter or letters of the divisor, when the result will be the quotient. Thus if it be

required to divide $25\,cd$ by $5\,c$, we divide the coefficient 25 by the other 5, which will give 5 for the coefficient of the quotient: and $c\,d$ being a product of which the c of the divisor is a factor, this symbol being expunged or taken away, the remaining symbol d will belong to the quotient, which will then be $5\,d$.

$$
\begin{array}{lllll}
5\,a\,m) & 5\,a^3m+25\,a\,b\,m-5\,a\,m^2\ (a^2+5\,b-m & & \\
 & 5\,a^3m & & \\
 & \overline{\quad\cdot\quad} & & \\
 & & +25\,a\,b\,m & \\
 & & 25\,a\,b\,m & \\
 & & \overline{\quad\cdot\quad} & \\
 & & & -5\,a\,m^2 \\
 & & & 5\,a\,m^2 \\
 & & & \overline{\quad\cdot\quad}
\end{array}
$$

In beginning this operation the divisor $5\,a\,m$ is to be taken out of the first term of the dividend $5\,a^3m$: taking the root a from the 3rd power, we have the 2nd power of a for a term of the quotient; and as 5 is contained once in 5, and m once in m, neither of these coefficients (*one*) need to appear in the quotient; they are therefore suppressed or expunged; and the divsor $5\,a\,m$ being multiplied by the quotient a^2, and the product $5\,a^3m$ written under the dividend is equal to it, and of course no remainder is left. The next term $25\,a\,b\,m$ is then brought down, and the 5 of the divisor being contained 5 times in the 25, 5 is placed as a coefficient in the quotient. Then $a\,m$ is contained b times in $a\,b\,m$; consequently $5\,b$ becomes the term of the quotient corresponding to this step of the division, which term multiplied into the divisor gives $25\,a\,b\,m$, to be subtracted without a remainder. Lastly comes down the term $-5\,a\,m^2$, out of which if we take the divisor $+5\,a\,m$, the quotient must be $-m$: hence the whole quotient in this operation will be a^2+5b-m. The same may be contracted by expunging the characters of the divisor from the dividend, in this way;

$$
5\,a\,m)\ \underline{5\,a^3m+25\,a\,b\,m-5\,a\,m^2}\ (
$$
$$
a^2\ +5\ \ b\ \ -\ \ m.
$$

2nd. When the divisor is simple, but not a factor or portion of any term of the dividend, the quotient must be expressed as a fraction, of which the numerator is the dividend, and the denominator the divisor: thus $48\,m$ divided by $9\,x$ can be expressed only as a fraction $\frac{48\,m}{9\,x}$.

3rd. When the divisor is complex, that is, contains more than one term, the first term of the dividend is divided by the first term of the divisor, and the quotient, being put down with the proper

sign, is multiplied into the whole of the divisor, for a product to be subtracted from the dividend. If any thing remain it becomes a new dividend, the first term of which is again divided by the first term of the divisor, and the quotient annexed, with the proper sign, to the foregoing term. Then the whole divisor is multiplied by this last part of the quotient, and the product subtracted from the last dividend; and so on as long as any thing remains, or at least until it be evident that something will always remain.

For example, divide $x^2+2xz+z^2$ by $x+z$.

$$\begin{array}{rl} x+z) & x^2+2xz+z^2\ (x+z \\ & x^2+xz \\ \hline & \qquad xz+z^2 \\ & \qquad xz+z^2 \\ \hline & \qquad \cdot \quad \cdot \end{array}$$

Here we inquire how often x the first term of the divisor is contained in x^2, the first term of the dividend: and as x^2 is the second power of x, or the product of x multiplied by x, it follows that if we divide the product by the root the quotient will be the same root; and multiplying by it the divisor, the product is x^2+xz which subtracted from the dividend will leave xz. To this bringing down the remaining term z^2, we have a new dividend $xz+z^2$. The inquiring how often we can have x of the divisor in xz, we see it can be taken z times: for x being one of the factors in the product, it is clear that z must be the other. This written in the quotient, with the sign $+$, because the signs of the divisor and dividend are like or the same, we next multiply the whole divisor by z, producing $xz+z^2$, equal to the last dividend.

Another example; where the dividend is found by the multiplication of $4a+b-5m$ by $a+2m$.

$$\begin{array}{r} 4a+b-5m \\ a+2m \\ \hline 8am+2bm-10m^2 \\ 4a^2+ab-5am \qquad \\ \hline \end{array}$$

$$\begin{array}{rl} a+2m) & 4a^2+8am+ab+2bm-5am-10m^2\ (4a+b-5z \\ & 4a^2+8am \\ & \overline{\cdot \qquad \cdot} \\ & \qquad\qquad ab+2bm \\ & \qquad\qquad ab+2bm \\ & \qquad\qquad \overline{\cdot \qquad \cdot} \\ & \qquad\qquad\qquad -5am-10m^2 \\ & \qquad\qquad\qquad -5am-10m^2 \\ & \qquad\qquad\qquad \overline{\cdot \qquad \cdot} \end{array}$$

Equations. In algebraic calculations it is generally the object, by means of certain known quantities, to discover others that are unknown, but which are stated to stand in given proportions or relations to those known quantities. This is done by discovering what portion of such known quantities is equal in value to the required quantities; and the statement of this value is termed an *equation*. In the equation $a+b-c=x$, if the values of $a\ b+c$ be known, their sum which is x must also be ascertained. An equation is said to be *resolved* when the known quantities are all placed on the one side of the sign of equality, and the unknown quantities on the other; and the value of the unknown quantities is called the *root* of the equation. When an equation expresses the mere value of a quantity it is a simple *equation*: when it contains the second power or the square of the unknown quantity, it is a *quadratic* equation; when it exhibits the third power or cube, it is a *cubic* equation; the 4th power constitutes a *biquadratic* equation, and so on with the higher powers. When the unknown quantity is connected with a known quantity and their conjunct value is also known, the unknown quantity may be transposed to the one side of the equation, and the known quantities to the other, as in this example, where the value of x is required, at the same time that if 8 be taken from x, the remainder will be 20; $x-8=20$.

$$x-8=20$$
$$x=20+8$$
$$x=28$$

Here we see that if 8 be taken from the value of x the remainder will be 20; consequently 20 and 8 must be equal to x; the 8 is therefore transposed to the opposite side of the equation with the sign $-$ changed to $+$.

Again, let $8x+4$ be equal to $12x-24$, required the value of x.

$$8x+4=12x-24$$
$$8x=12x-24-4$$
$$8x=12x-28$$
$$8x-12x=4x=28$$
$$x=7.$$

Here as $8x$ is four less than $12x-24$, $8x$ alone must be equal to $12x-24-4$, or to $12x-28$; this last sum therefore 28 must be the difference between $8x$ and $12x$, that is equal to $4x$, consequently x must be the 4th part of 28, or 7: and that this is the case, may be easily shown in this way. The question states that $8x+4$ are equal to $12x-24$: 8 times 7 are 56, and adding 4 we have 60: again, 12 times 7 are 84, from which subtracting 24, we have 60 as before.

Of the general nature of algebraic operations, the foregoing observations may be sufficient to convey some notion to the reader; and to enter more deeply into such a subject would be unsuitable to a work of this kind: it remains therefore just to give a specimen or two of the kind of questions, in the solution of which algebra is employed.

1st. Two friends A. and B. each riding his own horse, set out on the same day and at the same hour, from London and Edinburgh, for the purpose of meeting upon the road. A. proceeded from London at the rate of 24 miles every day, and B. travelled from Edinburgh at the rate of 20 miles every day. It is now desired to say at what time and at what point of the road the friends will meet, the distance between the towns being 396 miles? Let z represent the number of days travelled by each before meeting: then A's. journey will be represented by $24z$, and B's. by $20z$: and as the sum of the two journeys must be equal to the whole distance between the towns, we proceed in the following way.

$$\begin{aligned} && \textit{miles} \\ 24z+20z &= 396 \\ 44z &= 396 \\ z &= \frac{396}{44} \\ z &= 9 \end{aligned}$$

Thus we find the number of days each travelled to be 9: which may be proved by computing the several distances. 9 times 24 are 216 miles for A's. journey: 9 times 20 are 180 miles for B's journey; and both together make 396 miles: so that the friends would meet at a spot 216 miles north from London, and 180 miles south from Edinburgh, between Boroughbridge and Wetherby in Yorkshire.

2nd. A shepherd being asked what number of sheep were in each of two flocks placed under his management, answered that the amount of the two together was 1200 sheep, and that the difference between the two flocks was just one tenth part of the amount of both together; required the number of sheep in each flock?

Call the greater flock x, and the smaller z: then from the terms of the question we have this equation:

The sum of the two flocks is given 1200, and the difference between them is one tenth part of that sum or 120. The amount of these two quantities must therefore be 1320: but as in this amount the value of x is twice mentioned as is that of z, but with this difference, that in the one case it is added, and in the other subtracted, the value of z therefore may be expunged or taken away, and twice the value of x will remain 1320, and consequently x itself must be 660. Now according to the question, the difference between the flocks was 120, consequently the smaller flock must consist of only 540 sheep, which with the 660 will give 1200 sheep for the amount of both as stated in the question.

$$\begin{aligned} x+z &= 1200 \\ x-z &= 120 \\ x+z+x-z &= 1200+120 \\ 2x &= 1320 \\ x &= 660 \\ z &= 660-120 \\ z &= 540 \end{aligned}$$

3rd. A person wishing to try the skill of one who asked him what money was in his pocket, answered if to what I have you add

its half, its third, and its fourth part, the whole amount will be just £75: how much money had this person in his pocket? Let x represent this sum, then the statement will be $x+\frac{x}{2}+\frac{x}{3}+\frac{x}{4}=75$: and to get rid of the fractions take any number convenient, by which to multiply all the terms of the equation, as suppose 12, when we will have this equation.

$$12x+\frac{12x}{2}+\frac{12x}{3}+\frac{12x}{4}=900$$

$$\text{or } 12x+6x+4x+3x=900$$

$$25x=900$$

$$x=36.$$

The value of x is thus found to be 36 pounds; which will answer the terms of the question, for 36 with its half 18, its third 12, and its fourth part 9, will just make up £75.

CHAP. V.

OF LOGARITHMS.

IN every branch of calculation it is of the utmost importance to shorten the operations, not only for the saving of time but for the avoiding of chances of error which, in tedious and complicated computations, must necessarily often occur. To attain this most desirable object various methods have at different periods been proposed: but none with such certainty of advantage as the method by *logarithms*, which was first made public just two hundred years ago; and is now universally adopted and employed, by men of science in every part of the world. *Logarithms* is a Greek term signifying the proportion of numbers: they were invented by *John, Lord Napier, of Merchiston* near Edinburgh in Scotland, who in 1614 gave to the world tables of these artificial numbers. No sooner was this admirably useful invention made known, than ingenious men, in various parts of Europe, set themselves with earnestness to understand and improve so valuable a discovery. It was however to the celebrated *Henry Briggs*, first of Gresham college in London, afterwards professor of geometry at Oxford, that the world was chiefly indebted for various improvements in logarithms: for he travelled more than once down to Edinburgh, an enterprise of no common energy in those troublesome times, to visit and confer with Lord Napier; and to the interchange of conceptions, between those two geometricians of the first order, the world owes the perfect simplicity and utility of modern logarithms.

Nature and uses of Logarithms.

If we take a set of numbers, increasing in any given proportion, such as that each succeeding number shall be double the number immediately before it, (which is what is called *geometrical* proportion) such as 1, 2, 4, 8, 16, 32, 64, 128, 256, &c. and opposite

to them place another set of numbers increasing by *arithmetical* progression, such that each succeeding number shall be 1 more than the number immediately before it, as 1, 2, 3, 4, 5, 6, 7, 8, 9, &c. this curious effect and property will be found that, by simply adding together these last numbers, and observing that number of the first set opposite to which this sum stands, we at once discover the product which would have been obtained by the multiplication of the two quantities in the set of geometrical progressionals, to which the arithmetical progressionals correspond. This will be more intelligible from a consideration of this table.

Table 1st.

1	2	4	8	16	32	64	128	256	512
0	1	2	3	4	5	6	7	8	9

The upper row of numbers in this table contains a set increasing regularly in such a geometrical proportion, that each succeeding number is double its predecessor: thus 2 are double 1, 8 double 4, 512 are double 256. In the lower row are a set of numbers increasing arithmetically by the addition of one; and these lower numbers are indexes of the number of reduplications, by which the upper set have been respectively increased. Thus 1 in the upper row being the original stock of the whole, before the doubling has begun, the index 0 in the lower row expresses that it has not been doubled: 1 in the lower marks that 2 in the upper has been once doubled; 2 in the lower row points out that 4 in the upper has been twice doubled; 4 shows that the corresponding 16 is the product of four reduplications, 9 marks that 512 is the result of 1 nine times doubled.

Table 2nd.

1	10	100	1000	10,000	100,1000	1,000,000
0	1	2	3	4	5	6

Again in this table the numbers in the upper row proceed in a tenfold geometrical proportion, each succeeding number being ten times its immediate predecessor; and the lower row of numbers increasing in an arithmetical proportion by one, point out how often the upper numbers opposite to each have undergone this tenfold multiplication. The zero or nought is placed opposite to the original number 1: but 2 indicates the number above it to be produced by two multiplications by 10: for 10 times 1 are 10, and 10 times 10 are 100. The index 4 shows that 10,000 is produced by 4 multiplications by 10; and 6 marks the six multiplications by 10, by which 1 is increased to one million. In both the tables here given as specimens (for the rate of increase may be varied at pleasure) the numbers in the lower row, increasing by the addition of 1, are the *logarithmic* numbers corresponding to the *natural* numbers increasing by a much more rapid augmentation in the upper row. As an example of the nature and use of these

logarithmic numbers, let us suppose it were required to find the product of 4 multiplied by 8 in table 1st. Under 4 in the upper row or the natural numbers we have 2 for its logarithm, and under the natural number 8 we have 3 for its logarithm. Then *adding* these two logarithms 2 and 3 together, we have 5 for the logarithm of the product; and over 5 we find 32 the natural product from *multiplying* 4 by 8. Again, to multiply 4 by 16, and their product again by 8, we add together the three logarithms 2, 4, and 3, standing respectively under 4, 16, and 8; and the sum 9 is the logarithm in the lower row, above which is 512, the product of the successive multiplications of 4 into 16, and their product by 8. In the same way in table 2nd, when the natural numbers augment in a tenfold proportion, if we wanted to know the product of 10 by 1000, we would simply add together the indexes under 10 and 1000, which are 1 and 3, and above 4 their sum, we would find 10,000, the product required. If we wanted to discover the value of 10 multiplied by 100, and their product by 1000, we have only to add together the logarithms in the lower row corresponding to those natural numbers, viz. 1, 2, and 3, amounting to 6, over which logarithm we find 1,000,000, the ultimate product required.

On the other hand, to divide any given number by another, all we have to do is from the logarithm of the greater number to subtract that of the less, when the remainder will be the logarithm of the quotient: thus let it be required to divide 512 by 8 in table 1st. From 9 the logarithm standing under the dividend 512, subtract 3 the logarithm under the divisor 8, and 6; the remainder, is the logarithm of 64 the quotient of 512 divided by 8. To divide 1,000,000 by 10,000 in table 2nd, from 6 the logarithm of the dividend, we take away 4 the logarithm of the divisor, when the remainder 2 is the logarithm standing under 100, the desired quotient.

To square any number, as 8, we have only to double the logarithm in table 1st, which is 3 making 6, above which we have 64 which is the square of 8: and the cube of 8 will be found by taking three times its logarithm 3 or 9 which stands under 512 the cube of 8. Again, to extract the square root of any given sum as 64, we have only to take one-half of its logarithm 6 or 3 which is the logarithm of 8, the square root of 64 that was wanted: and the cube root of any quantity as 512 will be found by merely taking the third part of its logarithm 9, which is 3, the logarithm of 8 the cube root of 512 that was required.

From the specimens here exhibited the reader will be enabled to form a notion of the nature and uses of logarithms; of which the calculation, to compose tables applicable to a great extent of numbers up from unity, is an operation of prodigious labour; but this labour, thanks to our forefathers, is now rendered unnecessary for their not over grateful posterity: sets of ample and accurate logarithms are now to be found published not only by themselves, but in almost every work upon the application of geometry to the businesses of life, where their aid is required. According to the mode now adopted in constructing logarithmic tables, by which the natural numbers increase in a tenfold proportion, the logarithm of 1 or unity being 0, that of 10 is 1, that of 100 is 2, that of 1000

3, that of 10,000 is 4, &c.: or in other words, the integral part of the ›garithm is always one less than the number of figures in the natural umber. This integral part is called the *characteristic* or *index* of ıe logarithm, because it points out and determines the number f places of figures in the corresponding natural number. Thus he index 0 belongs to all numbers under 10; 1 belongs to all in- luding and from 10 to and including 99; 2 to all including 999, ⁊c. Hence also it follows that numbers differing from one nother in a tenfold proportion, will have the fractional part of heir logarithms all the same, but the integral part or index varying ccording to the number of figures in the several numbers. Thus ı the figures of the year 1814.

Nat. numbers		Logarithms
1814.	=	3.258637
181.4	=	2.258637
18.14	=	1.258637
1.814	=	0.258637

That the reader may learn the manner of using tables of logarithms f natural numbers, a specimen is here introduced, comprising all ıumbers from one to one hundred.

LOGARITHMS OF NATURAL NUMBERS.

N.	Log.	N.	Log.	N.	Log.	N.	Log.
1	0.00000	26	1.41497	51	1.70757	76	1.88081
2	0.30103	27	1.43136	52	1.71600	77	1.88649
3	0.47712	28	1.44716	53	1.72428	78	1.89209
4	0.60206	29	1.46240	54	1.73240	79	1.89763
5	0.69897	30	1.47712	55	1.74036	80	1.90309
6	0.77815	31	1.49136	56	1.74819	81	1.90849
7	0.84510	32	1.50515	57	1.75587	82	1.91381
8	0.90309	33	1.51851	58	1.76342	83	1.91908
9	0.95424	34	1.53148	59	1.77085	84	1.92428
10	1.00000	35	1.54407	60	1.77815	85	1.92942
11	1.04139	36	1.55630	61	1.78533	86	1.93450
12	1.07918	37	1.56820	62	1.79239	87	1.93952
13	1.11394	38	1.57978	63	1.79934	88	1.94448
14	1.14613	39	1.59106	64	1.80618	89	1.94939
15	1.17609	40	1.60206	65	1.81291	90	1.95424
16	1.20412	41	1.61278	66	1.81954	91	1.95904
17	1.23045	42	1.62325	67	1.82607	92	1.96379
18	1.25527	43	1.63347	68	1.83251	93	1.96848
19	1.27875	44	1.64345	69	1.83885	94	1.97313
20	1.30103	45	1.65321	70	1.84510	95	1.97772
21	1.32222	46	1.66276	71	1.85126	96	1.98227
22	1.34242	47	1.67210	72	1.85733	97	1.98677
23	1.36173	48	1.68124	73	1.86332	98	1.99123
24	1.38021	49	1.69020	74	1.86923	99	1.99565
25	1.39794	50	1.69897	75	1.87506	100	2.00000

The foregoing table is used in this way: if I want the logarithm of any number within its limits as 64, I look for that number in the narrow column of natural numbers marked N. at the top, and on the same line, in the broad column on the right hand, marked Log. I find 1.80618: in the same way the logarithm of 5 will be found 0.69897, and that of 100 is 2.00000. Again, if the natural number corresponding to any given logarithm be required, I search in the column of logarithms for the one given, and on the left hand in the column of numbers is what I want: thus if the logarithm 1.80618 be wanted, by tracing the order of the figures I meet with it, and on the left the natural number corresponding, which is 64. In the course of calculations however, it frequently happens that we have occasion for natural numbers, higher than the tables contain, as for example, the table here given goes only to include 100, but I want the logarithm of 144. The fractional part of the logarithm 140, which is the nearest below 144, being the same with that of 14, I take it from the table, which is .14613: in the same way I take the fractional part of the logarithm for 15, the same with that for 150, the nearest number above 144, which is .17609. The difference between these two fractions is .02996, corresponding to 10 the difference between 140 and 150; but wanting to know how much 144 exceeds 140 in the fractional part, I state this proportion, as 10, the excess of 150 above 140, to the difference of fractions .02996, so 4 the excess of 144 above the same 140 to a fourth number, which, by the simple rule of three, will turn out .01198. This quantity added to .14613 the fractional part for 140, will give .15811 as the fractional part of the logarithm of 144; and this number consisting of three figures, the index or characteristic must be 2, consequently the logarithm of 144 must be 2.15811.

Multiplication is performed in logarithms as in this example, where it is required to multiply 12 by 8. Find in the tables the logarithms of these numbers: add them together, and in the column of logarithms look for the sum or the nearest to it, when the natural number opposite to it will be the required product.

$$\left.\begin{array}{r} \text{Logarithm of } 12 \text{ is } 1.07918 \\ \underline{\qquad\qquad} 8 = 0.90309 \end{array}\right\} \text{add}$$

$$\text{product } 96 = 1.98227$$

Again, 3 by 5, and the product by 6.

$$\text{multiply} \left\{\begin{array}{r} \text{Logarithm of } 3 \text{ is } 0.47712 \\ \underline{\qquad\qquad} 5 = 0.69897 \\ \underline{\qquad\qquad} 6 = 0.77815 \end{array}\right\} \text{add}$$

$$\text{product } 90 = 1.95424$$

Division is performed by subtracting the logarithm of the least quantity from that of the greatest, when the difference will be the

logarithm of the quotient, as here where 96 must be divided by 12.

Logarithm of 96 is		1.98227	
——	12 =	1.07918	subtract
quotient	8 =	0.90309	

Again, divide 90 by 6, and the quotient by 5.

Logarithm of 90 is		1.95424	
——	6 =	0.77815	subtract
Quotient	15 =	1.17609	
Logarithm of	5 =	0.69897	subtract
Quotient	3 =	0.47712	

In these examples the great utility of logarithms cannot be very apparent, because only such small numbers as come within the specimen of the tables are chosen: but when considerable numbers are employed, as in the following examples, the advantages of logarithms will be evident. Suppose it were required to multiply 98730 by 5865; by logarithms the operation is performed very speedily, in this way.

Logarithm of	98730 =	4.99445	add
——	5865 =	3.76827	add
Product	579051450 =	8.76272	

This multiplication done in common numbers is not only tedious but subject to mistakes, which can scarcely occur in the above short operation.

As all quantities and magnitudes may be expressed by numbers, tables have been calculated applicable to geometrical operations, founded on the nature and proportions of certain parts of circles and triangles, such as sines, tangents, and secants: but the nature and uses of these last tables must be reserved for the introduction to *Practical Geometry*.

CHAP. VI.

BOOK-KEEPING.

BY *Book-keeping* or *merchants' accounts* is meant the method of recording, with order and accuracy, all mercantile or commercial transactions.

By *book-keeping* the merchant or trader obtains a particular and complete statement of every branch of his affairs, exhibiting the profit or loss arising from each separate transaction, as well as from the whole course of his business, and affording satisfactory information on all matters in which, as a man of commercial or mercantile business, he is concerned.

A merchant's books should contain an account of the whole amount of his property employed in trade, consisting in cash, bills, public funds, goods in hand, ships, houses, lands, debts due to him, &c. By comparing the state of these several sorts of property, from time to time, he will learn the true situation of his affairs, discover whether they be prosperous or the contrary, and thence be enabled to manage them to the best advantage.

Various modes of book-keeping have been adopted in the mercantile world: but that which is generally followed is book-keeping by *double entry*. This is usually called the *Italian* method, having been carried into other countries from the northern parts of Italy.*

* To Italy the other states of Europe are indebted for the first principles of religion and literature, of science and of art. The inhabitants of the northern parts of Italy, known by the general name of Lombardy, comprehending the powerful commercial republics of Genoa, Pisa, and Venice, travelled to and established themselves in all those countries where mercantile transactions promised the due recompense of their labour and risk. Occupying particular quarters or streets of the places where they fixed their abode, the name of *Lombard street* is still preserved in London, Paris, and other principal towns of Europe. Exhibiting their wares for sale on a *bench* (in Italian, *banco*) these traders came to be called *bankers*; and when they were unable to discharge their debts, their bench was broken, or at least taken from them: hence the Italian *banco-rotto*, the French *banque-route*, and the English *bankrupt*. By lending money for interest upon goods, particularly upon gold and silver vessels, jewels, &c. deposited in their hands, they obtained the appellations of *silver-smiths* and *pawn-brokers*. The golden or blue balls adopted in many places, as the emblems of their shops, have a reference to the arms of the Grand Duchy of Tuscany in Italy, from which many known as Lombards originally came.

In books of *single entry*, only such articles are recorded as are bought or sold on credit; no account being kept of those bought or sold for ready money or other immediate payment. The consequence of this is that the books can furnish no complete statement of the trader's concerns, unless assisted by taking the stock of goods remaining unsold, and so calculating the amount of gain or loss on his transactions. *Single entry* is therefore applicable only to small dealings or retail business. Book-keeping by *double entry* is, on the contrary, adapted to large, extensive and complicated commercial transactions: for it possesses this great advantage, that by merely inspecting each account, or the periodical balances of his whole concerns, the merchant can at once form a correct notion of the state of his affairs.

In keeping accounts by *single entry* two books are required, the *Day-book* and the *Ledger*. The day-book contains a statement of the trader's property in business, followed by a description of each transaction in the order in which it occurs. The Ledger comprises in one account, under the name of each person, the several occurrences of the day-book in which that person is concerned; the different articles in which he may be debtor or creditor, being entered in opposite pages, and thus furnishing a state of the trader's affairs with that person. The manner of keeping these two books will be readily understood from the following specimen of accounts kept by single entry.

On the 11th of April 1814, I purchase, on credit, from Richard Wilson, 124 yards of silk at 5s. 8d. per yard; value in all £35..2..8. On the 15th of the same month I sell to Joseph Andrews, on credit, 85 yards of that silk at 7s. 1½d. per yard, amounting to £30..5..7½. On the 18th Joseph Andrews pays to me £20..5..7½, in part of his account for silk. On the 20th of the same month, I pay to Richard Wilson £15..2..8 in part of my debt to him. In the day-book these articles appear in this way:

DAY-BOOK.

Folio of Ledger.		£	S.	D.
	11th April, 1814			
	Richard Wilson Cr.			
2	By *Silk*, for 124 yards, at 5s. 8d. per yard..	35	.2	.8
	15th.			
	Joseph Andrews Dr.			
2	To *Silk*, for 85 yards, at 7s. 1½d. per yard..	30	.5	.7½
	18th.			
	Joseph Andrews Cr.			
1	By *Cash* received in part	30	.5	.7½
	20th.			
	Richard Wilson Dr.			
1	To *Cash* paid to him in part	15	.2	.8

In the Ledger these articles will appear in the following manner.

(1) LEDGER.

			Fo.	£	S.	D.
1814		*Richard Wilson* Dr.				
April	20	To *Cash* paid him in part ..	1	15	.2	.8
		To *Balance*		20	00	00
				35	.2	.8
1814		*Joseph Andrews* Dr.				
April	15	To *Silk*, for 85 yards at 7s. 1½d. per yard	2	30	.5	.7½

Here it is to be observed that as the person who receives any money or article of merchandise becomes the debtor, and the person who gives away any money or article of merchandise becomes the creditor; having purchased silk on credit from Richard Wilson, I become his debtor and he becomes my creditor for the value of the goods: his name is therefore entered in the day-book as creditor for a certain quantity of silk at a certain value, and the amount is placed in the money columns.

In the next transaction where a part of that silk is sold on credit to Joseph Andrews, he is entered as debtor to me for the value: and in the following occurrence when he pays me a part of his debt, I give him credit for that partial payment; that is, he appears in the book as creditor for that amount.

In the last transaction, by paying to Richard Wilson a part of what I owe him, that by giving him a sum of money, he is entered as debtor to me, or he is debited for that amount.

In this way is the day-book filled up; but in the Ledger a separate account is allotted for each person with whom I have dealings: room being left to enter all the transactions expected

LEDGER. (1)

1814		*Contra* *Cr.*	Fo.	£	S.	D.
April	11	By *Silk*, for 124 yards, at 5s. 8d. per yard	2	35	. 2	. 8
1814		*Contra* *Cr.*				
April	18	By *Cash* received from him in part	1	20	. 5	. 7½
		By *Balance*		10	00	00
				30	. 5	. 7½

to take place between each person and me. This book is laid out in *folios* (from the Italian name for the leaf of a book,) each folio consisting of two opposite pages from adjoining leaves of paper, and both numbered with the same figure expressing the folio.

In the example here given the name of Richard Wilson appears at the head of his account, on the left hand of the folio, appropriated to the debtor side. On the right hand is written the Latin word *contra* (meaning *against* or *on the other hand)* for the creditor side, in which, as he is my creditor for the silk purchased but not paid for by me, I enter the date, nature, and value of the transaction.

Again, an account is opened for Joseph Andrews, similar to that for Richard Wilson: but as by my parting with goods to him upon credit, he becomes my debtor, the date, nature, and value of the transaction are entered on the debtor side of the folio.

When Joseph Andrews pays me a part of his debt I give him credit for that payment, and enter the amount on the creditor side of his account: but when out of the money thus received I discharge a part of my debt to Richard Wilson, I consider the latter

as debtor (that is to say, as being accountable) to me for the sum paid to him, and therefore enter it on the debtor side of his account.

The transactions of a certain period of time being all entered in the ledger, it next becomes necessary to balance the accounts. This is done by subtracting the less side from the greater and placing the difference on the less side. Thus in Richard Wilson's account, my debt to him is £35..2..8, of which, having paid £15..2..8, the remainder £20..0..0 still unpaid, is placed under the sum paid, making the whole equal to the amount of his credit upon me £35..2..8. On the other hand Joseph Andrews being indebted to me £30..5..7½ for goods delivered on credit, and having afterwards paid in part £20..5..7½, the difference or balance due to me is entered on the creditor side of his account, making that equal to the debtor side.

By books kept in this way by single entry, I can see that I still owe £20 to Richard Wilson, and that Joseph Andrews still owes me £10; but I cannot at a look discover the correct state of my affairs: it will therefore be necessary *to take stock*, as it is termed, that is to inquire what goods are still upon my hands unsold. Of 124 yards of silk purchased from Richard Wilson I sold 85 yards to Joseph Andrews; 39 yards therefore remain unsold, which, valued at prime cost, or 5s. 8d. per yard, will be worth £11..1. This added to the £30..5..7½, the price of the quantity sold to Joseph Andrews, will give £41..6..7½, exceeding the prime cost of the whole silk £35..2..8, by £6..3..11½, which last sum I consider as the profit already gained on the adventure. But as I have paid Richard Wilson only £15..2..8, and therefore still owe him £20, I find that by giving him the whole of the money received from Joseph Andrews I would reduce my debt from £20 to £14..7..0½.

From this example the defects of book-keeping by single entry must be obvious, particularly when we advert to the difficulty of taking the stock on hand of a merchant of complicated and extensive dealings, an operation of itself of much labour, as well as liable to error and even to fraud. The method by double entry is therefore, in such cases constantly to be adopted, agreeably to the following instructions and examples.

In book-keeping by *double entry*, three books are chiefly requisite, namely, the *Waste-book*, the *Journal*, and the *Ledger*.

The *Waste-book* contains, in simple clear language, a circumstantial and complete account or narrative of all transactions in business, in the order in which they occur.

The *Journal* contains an account of the same transactions, but expressed in a more artificial way, so as to point out the debtor and creditor in each case, and thereby to prepare the several articles for entrance in the ledger.

In stating the debtor and creditor in an account, the following general rules are to be observed.

1st. That every article received, or every person accountable to us is called the debtor.

2nd. That every article delivered, or every person to whom we are accountable is the creditor. Or more particularly:——the person to whom, or for whom we pay money, or furnish goods, is the Dr. and the person from whom, or for whom we receive money or goods is the Cr. Every thing which comes into our possession, or under our direction is the Dr. and every thing which goes out of our possession, or from under our direction is the Cr.

The following cases comprehend the most common occurrences in merchants' accounts.

1st. The person to whom any thing or article is delivered becomes Dr. to the thing or article delivered, when nothing is received in return.

2nd. A thing received is Dr. to the person from whom it is received, when nothing is delivered in return.

3rd. A thing received is Dr. to the thing given for it.

4th. Goods and all other *real* accounts, that is such as relate to property of every sort, are Drs. for all charges incurred for their sake.

5th. When any profits are received from real accounts, as rents of houses, freights of ships, bounties or drawbacks on goods exported or imported, and the like, *cash* becomes Dr. for the amount received, to the account or article from which the profit is derived.

N. B. The term *cash* is a corruption of the French word *caisse*, from the Italian *cassa*, signifying the chest, coffer, or strong box, in which money was formerly preserved: and as this money consisted then in the precious metals only, the contents of the *caisse*, or strong box, came to be known by the name of the place where it was deposited; and hence *cash* came to be employed for metallic money or coin, called also *specie*, in opposition to bank notes, bills, bonds, or any other kind of paper-money.

6th. When any loss is sustained the account of profit and loss, or some other account of the same import, is Dr. to *cash*, for the amount.

7th. When any profit or gain arises, but not from any *real* account, cash, the article received, or the person accountable for the profit, is Dr. to the account of profit and loss, or to some other account of the same nature, for the amount.

8th. When one person pays money, or delivers any thing to another person, on account, the receiver is Dr. to the person who pays or delivers.

The *Ledger*.——In this book all transactions belonging to one person or one article of merchandise are collected together and entered as they occur, under one head, expressing the person or thing concerned in the account: and as in every transaction there must be a Dr. and a Cr. the occurrence is entered in the accounts of both, on opposite sides; a circumstance from which book-keeping by *double entry* has obtained its name.

All accounts in the ledger are are either *real*, or *personal*, or *fictitious*. In *personal* accounts the person is entered Dr. or Cr. according to the nature of the transaction, as is done in accounts

kept by single entry. In *real* accounts each article is entered on the Dr. or Cr. side agreeably to the entries in the journal. In *fictitious* accounts all articles appear to have relation to stock, or to profit and loss. By stock is meant the merchant himself to whom the books belong; for his name never appears in his own books. On the Dr. side of this account appears the debts owing by the merchant; while on the Cr. side appears the monies due to him, with cash, goods, ships, and all other property belonging to him, in the outset of his business and books. By profit and loss, is understood whatever may be gained or lost in business: the Dr. side showing the loss, and the Cr. side the gain upon every transaction.

The following is a specimen of the mode of keeping a set of books by double entry, or the Waste-book, Journal, and Ledger.

WASTE-BOOK.

London, 1st March, 1814.

		£	S.	D.	£	S.	D.
	INVENTORY of the money, goods, and debts belonging to me A. B. as also of what I owe to others.						
√	I have in *ready money*	500	00	0			
	Bills receivable, one on *Philip Hawkins*, due 15th May next	195	00	0			
	Cloth 18 pieces each 25 yards at 17s. 6d. per yard	393	15	0			
	Sugar 12hds. containing in all 168cwt. at £3..15 per C.	630	00	0			
	Thomas Brown owes me	50	00	0			
					1768	15	00
	I owe as follows, viz.						
√	To *William Herbert*,	250	00	0			
	Bills payable, for my acceptance of *David Murray's* bill due on the 1st of June next	350	00	0			
					600	00	00
	4th March						
√	Sold for ready money 8 pieces of *cloth*, each 25 yards, at 19s. 4. per yard				193	06	08
	7th.						
√	Bought for ready money 40 pieces of *linen*, each 24 yards, at 3s. 3d. per yard				156	00	00
	9th.						
√	Bought of *Thomas Brown*, 50 gallons of *rum*, at 18s. per gallon				45	00	00

Waste-book.

		£	S.	D.
	9th March			
√	Sold *James Aldworth* 8hhds. *sugar*, containing 112cwt at £4..8 per cwt.	492	16	00
	12th.			
√	Sold *Thomas Ellis* 30 pieces of *linen* each 24 yards, at 4s. 2d. per yard. Received in part £50 00 00 The rest to be paid in 2 months 100 00 00	150	00	00
	15th.			
√	Bought of *Robert Turner* 42 pieces of *muslin*, averaging each 15 yards, at 3s. 10½d. per yard. Paid in part £52 01 03 Rest due at 3 months 70 00 00	122	01	03
	18th.			
√	Sold *George Fanshaw* the following goods, viz. 6 pieces of *cloth*, each 25 yards, at 19s. 6d. per yard £146 05 00 4hhds. of *sugar* containing 56cwt. at £4..7 per cwt. 243 12 00 10 pieces of *linen*, each 24 yards at 4s. 6d. per yard 54 00 00	443	17	00
	For which received in part in cash £43 17 00 A bill on *Jones and Co.* No. 25, due 20th April 200 00 00	243	17	00

WASTE-BOOK.

		£	S.	D.
	—— 21st March ——			
√	Paid to *William Herbert* on account	50	00	00
	—— do. ——			
√	Drawn on *Thomas Ellis* for the balance due on his account, payable at two months	100	00	00
	—— 28th. ——			
√	Received for the use of *James Allan* £1500 which I have remitted to him this day, deducting ½ per cent. for my commission	7	10	00
	—— 31st. ——			
√	Received the value of a legacy	100	00	00
	—— 2nd April ——			
√	Paid various charges for rent, &c. for last month	35	15	00
	—— do. ——			
√	Bought of *Rowland Hill* the following goods, to pay at two months, viz. 42 pieces of callico, each 23 yards, at 2s. 4d. per yard } £112 14 00 3 bags of *cotton* valued at £100 00 00 1 pipe of Port wine 83 17 00	296	11	00

WASTE-BOOK.

		£	S.	D.
	Shipped these goods on board the Bee, Peter Perry master, for Gottenburgh, for account and risk of *Walter Barnard* merchant there, as per Invoice rendered. Amount of goods £296 11 00 Charges of shipping, &c. 17 07 08 Commission at 2½ per cent. 7 16 11½	321	15	07½
	4th April			
✓	Sold for ready money 16 pieces of muslin at £3..13..6 per piece	58	16	00
	6th.			
✓	Sold to *Robert Turner* 4 pieces of cloth, each 25 yards, at 19s. 7d. per yard	97	18	04
	8th.			
✓	Lost a Bank note of	10	00	00
	11th.			
✓	Received per the Mary from Gottenburgh, 10 tons of hemp, to sell on account of *Walter Barnard* merchant there. Sold *William Herbert* 6 tons of the said hemp, to pay at two months } £240 00 00 Sold the remaining 4 tons for ready money } 152 00 00	392	00	00
	Commission on do. at 2½ per cent. } £ 9 16 00 Charges paid at landing 17 14 00	27	10	00
	Net proceeds due to *Walter Barnard*, as per account sales this day rendered	364	10	00

WASTE-BOOK.

		£	S.	D.
	14th April			
✓	Sold *William Herbert* 14 pieces of *muslin* at £3..16 per piece	53	04	00
	18th.			
✓	Sold to *David Hawkins*, 40 gallons of *rum*, at £1..0..8 per gallon	41	06	08
	20th.			
✓	Taken up my bill drawn in favour of *David Murray* due 1st June, for £350 00 00 Discount allowed by him, at 5 per cent. for 42 days £2 00 03	347	19	09
	25th.			
✓	*James Aldworth* being declared insolvent, and his creditors having agreed to accept at once a composition of 13 shillings in the pound, I have this day received my dividend on his debt to me for 8 hhds. sugar, amounting to £492..10.	320	06	08
	29th.			
✓	Received from *William Herbert* payment for the 14 pieces of muslin sold to him on the 14th of this month	53	04	00
	30th.			
✓	Paid various expences in this month, which are not charged to any other account	33	12	09

JOURNAL.

Fo.	London, 1st March, 1814.		£	S.	D.
	Sundries Drs. to *stock* For the amount of my effects				
1	*Cash*	£500 00 00			
2	*Bills receivable*, on *Philip Hawkins*	195 00 00			
2	*Cloth*, 18 pieces, each 25 yards, at 17s. 6d. per yard	393 15 00			
2	*Sugar*, 12hhds. containing 168cwt. at £3..15 per cwt.	630 00 00			
3	*Thomas Brown*	50 00 00			
			1768	15	00
	do.				
1	*Stock* Dr. to *sundries*, For the amount of what I owe				
3	To *William Herbert*	£250 00 00			
3	To *bills payable*, for *David Murray's* bill accepted by me, due 1st of June	350 00 00			
			600	00	00
	4th.				
1	*Cash* Dr. to *cloth*				
2	For 8 pieces, 200 yards, at 19s. 4d. per yard		193	06	08
	7th.				
3	*Linen* Dr. to *cash*				
1	For 40 pieces, each 24 yards, at 3s. 3d. per yard		156	00	00
	9th.				
4	*Rum* Dr. to *Thomas Brown*				
3	For 50 gallons, at 18s. per gallon		45	00	00

JOURNAL.

Fo.	9th March	£	S.	D.
4	*James Aldworth* Dr. to *sugar*			
2	For 8hhds. 112cwt. at £4..8 per cwt.	492	16	00
	12th.			
3	*Sundries* Drs. to *linen* For 30 pieces, each 24 yards, at 4s. 2d. per yard			
1	*Cash* received in part £50 00 00			
4	*Thomas Ellis* for the rest 100 00 00	150	00	00
	15th.			
4	*Muslin* Dr. to *sundries* For 42 pieces, each 15 yards, at 3s. 10½d. per yard			
1	To *cash* paid in part £52 01 03			
4	To *Robert Turner* for the rest 70 00 00	122	01	03
	18th.			
5	*George Fanshaw* Dr. to *sundries*			
2	To *cloth*, for 6 pieces, each 25 yards, at 19s. 6. per yard } £146 05 00			
2	To *sugar*, for 4hhds. 56cwt. at £4..7 per cwt. } 243 12 00			
3	To *linen* for 10 pieces, each 24 yards, at 4s. 6d. per yard } 54 00 00	443	17	00
	do.			
5	*Sundries* Drs. to *George Fanshaw*			
1	*Cash* £43 17 00			
2	*Bills receivable, Jones and Co.* due 20th April } 200 00 00	243	17	00

JOURNAL.

Fo.		£	S.	D.
	—— 21st March ——			
3 1	*William Herbert* Dr. to *cash* paid to him on account,	50	00	00
	—— do. ——			
2 4	*Bills receivable* Drs. to *Thomas Ellis*, for his acceptance of my bill at 2 months	100	00	00
	—— 28th. ——			
1 5	*Cash* Dr. to *commission* For receiving and remitting £1500, for *Richard Wilson*, at ½ per cent.	7	10	00
	—— 31st. ——			
1 5	*Cash* Dr. to *Profit and Loss*, For the value of a legacy received	100	00	00
	—— 2nd April ——			
1 5	*Profit and Loss* Dr. to *cash*. Rent and other charges paid for the last month	35	15	00
	—— do. ——			
5 5	*Merchandise.* Dr. to *Rowland Hill* For the following goods bought of him, at two months, viz. Callico 42 pieces, each 23 yards, at 2s. 4d. per yard } £112 14 00 *Cotton* 3 bags, valued at 100 00 00 *Port wine* 83 17 00	296	11	00

JOURNAL.

Fo.	2nd April	£	S.	D.
6	*Walter Barnard* Dr. to *sundries*			
	For goods shipped on his account and risk, on board the Bee, Peter Perry master, for Gottenburgh, as per Invoice			
5	To *merchandise*, for *sundries* £296 11 00			
1	To *cash*, for charges on do. 17 07 00			
5	To *commission*, at 2½ per cent. 7 16 11½			
		321	15	07½
	4th.			
1	*Cash* Dr. to *muslin*			
4	For 16 pieces, at £3..13..6 per piece	58	16	00
	6th.			
4	*Robert Turner* Dr. to *cloth*			
2	For 4 pieces, at £3..13..6 per piece	97	18	04
	8th.			
5	*Profit and loss* Dr. to *cash*			
1	For a Bank note lost, value	10	00	00
	11th.			
6	*Sales per the Mary* Dr. to *sundries*			
1	To *cash* for charges on merchandise, as per account of sales rendered £17 14 00			
5	To *commission* on £392..00, at 2½ per cent. 9 16 00			
6	To *Walter Barnard*, for net proceeds 364 10 00			
		392	00	00

JOURNAL.

Fo.	11th April	£	S.	D.
6	*Sundries* Drs. to *Sales per Mary* For ten tons of hemp on account of Walter Barnard of Gottenburgh			
3	*William Herbert*, for 6 tons, at 2 months £240 00 00			
1	*Cash* for remaining 4 tons 152 00 00			
		392	00	00
	14th.			
3	*William Herbert* Dr. to *muslin*			
4	For 14 pieces at £3..16 per piece	53	04	00
	18th.			
6	*David Hawkins* Dr. to *rum*			
4	For 40 gallons at 20s.8d. per gallon	41	06	08
	20th.			
3	*Bills payable* Dr. to *sundries* For David Murray's bill discounted,			
1	To *cash* paid to him £347 19 09			
6	To *interest* for discount 2 00 03			
		350	00	00
	25th.			
4	*Sundries* Drs. to *James Aldworth.*			
1	*Cash*, for my composition received £320 06 08			
5	*Profit and Loss*, for loss on his debt to me for sugar 172 09 04			
		492	16	00

JOURNAL.

Fo.	29th April	£	S.	D.
1 3	*Cash* Dr. to *William Herbert* Received from him for 14 pieces of muslin	53	04	00
	30th.			
5 1	*Profit and loss* Dr. to *cash* For various charges paid this month	33	12	09

End of the Journal.

Index of the Ledger.

A	Fo.	B	Fo.	C	Fo.
Aldworth James	4	Bills receivable	2	Cash	1
		Brown Thomas	3	Cloth	2
		Bills payable	3	Commission	5
		Barnard Walter	6		
		Balance	6		
D		**E**	**Fo.**	**F**	**Fo.**
		Ellis Thomas	4	Fanshaw George	5
G		**H**	**Fo.**	**I**	**Fo.**
		Herbert William	3	Interest	6
		Hill Rowland	5		
		Hawkins David	6		
K		**L**	**Fo.**	**M**	**Fo.**
		Linen	3	Muslin	4
				Merchandise	5
N		**O**		**P**	**Fo.**
				Profit and loss	5
Q		**R**	**Fo.**	**S**	**Fo.**
		Rum	4	Stock	1
				Sugar	2
				Sales per Mary	6
T	**Fo.**	**U**		**W**	
Turner Robert	4				

(1) LEDGER.

1814		STOCK Dr.	Fo.	£	S.	D.
March	1	To *Sundries*		600	00	00
April	30	To Balance for the net of my estate	6	1270	06	09½
		£		1870	06	09½

1814		CASH Dr.	Fo.	£	S.	D.
March	1	To *Stock*	1	500	00	00
	4	To *Cloth*	2	193	06	08
	12	To Linen	3	50	00	00
	18	To George Fanshaw	5	43	17	00
	28	To Commission	5	7	10	00
	31	To Profit and Loss	5	100	00	00
April	4	To Muslin	4	58	16	00
	11	To Sales per Mary	6	152	00	00
	25	To James Aldworth	4	320	06	08
	29	To William Herbert	3	53	04	00
		£		1479	00	04

LEDGER. (1)

1814		CONTRA Cr.	Fo.	£	S.	D.
March	1	By *Sundries*		1768	15	00
April	30	By Profit and Loss	5	101	11	09½
		£		1870	06	09½

1814		CONTRA Cr.	Fo.	£	S.	D.
March	7	By *Linen*	8	156	00	00
	15	By Muslin	4	52	01	03
	21	By William Herbert	3	50	00	00
April	2	By Profit and Loss	5	35	15	00
	—	By Walter Barnard	6	17	07	08
	8	By Profit and Loss	5	10	00	00
	11	By Sales per Mary	6	17	14	00
	20	By Bills payable	3	347	19	09
	30	By Profit and Loss	5	33	12	09
	—	By Balance	6	758	09	11
		£		1479	00	04

1814		Bills receivable Dr.	Fo.	£	S.	D.
March	1	To Stock	1	195	00	00
	18	To George Fanshaw	5	200	00	00
	21	To Thomas Ellis	4	100	00	00
		£		495	00	00

1814		Cloth Dr.	Fo.	£	S.	D.
March	1	To Stock, 18 pieces, 450 yards, at 17s. 6d. per yard	1	393	15	00
April	30	To Profit and Loss	5	43	15	00
		£		437	10	00

1814		Sugar Dr.	Fo.	£	S.	D.
March	1	To Stock, 12hhds. 168cwt. at £3..15 per cwt.	1	630	00	00
April	30	To Profit and Loss	5	106	08	00
		£		736	08	00

LEDGER. (2)

			Fo.	£	S.	D.
1814		CONTRA CR.				
April	30	By Balance		495	00	00
		£		495	00	00
1814		CONTRA CR.				
March	4	By Cash, 8 pieces, 200 yards, at 19s. 4d. per yard	1	193	06	08
	18	By George Fanshaw, 6 pieces, 150 yards, at 19s. 6d. per yard	5	146	05	00
April	6	By Robert Turner, 4 pieces, 100 yards, at 19s. 7d. per yard	4	97	18	04
		£		437	10	00
1814		CONTRA CR.				
March	9	By James Aldworth, 8hhds. 112cwt. at £4 . . 8 per cwt.	4	492	16	00
	18	By George Fanshaw, 4hhds. 56cwt. at £4 . . 7 per cwt.	6	243	12	00
		£		736	08	00

1814		THOMAS BROWN Dr.	Fo.	£	S.	D.
March	1	To Stock	1	50	00	00
				50	00	00

1814		WILLIAM HERBERT Dr.	Fo.	£	S.	D.
March	21	To cash paid him to account	1	50	00	00
April	11	To Sales per Mary	6	240	00	00
	14	To Muslin	4	53	04	00
		£		[illegible]	04	[illegible]

1814		BILLS PAYABLE Dr.	Fo.	£	S.	D.
April	20	To Sundries as per journal		350	00	00
				350	00	00

1814		LINEN Dr.	Fo.	£	S.	D.
March	7	To Cash, 40 pieces, 960 yards, at 3s. 3d. per yard	1	156	00	00
April	30	To Profit and loss	6	48	00	00
		£		204	00	00

LEDGER. (3)

1814		CONTRA Cr.	Fo.	£	S.	D.
March	9	By Rum	4	45	00	00
April	30	By Balance	6	5	00	00
		£		50	00	00

1814		*Contra* Cr.	Fo.	£	S.	D.
March	1	By Stock	1	250	00	00
April	29	By Cash for muslin	1	53	04	00
	30	By Balance	6	40	00	00
		£		343	04	00

1814		*Contra* Cr.	Fo.	£	S.	D.
March	1	By Stock, for David Murray's bill	1	350	00	00
		£		350	00	00

1814		*Contra* Cr.	Fo.	£	S.	D.
March	12	By Sundries, 30 pieces, 720 yards, at 4s. 2d. per yard		150	00	00
	18	By George Fanshaw, 10 pieces, 240 yards, at 4s. 6d. per yard	5	54	00	00
		£		204	00	00

(4) LEDGER.

1814		Rum Dr.	Fo.	£	S.	D.
March	9	To Thomas Brown, 50 gallons, at 18s. per gallon	3	45	00	00
April	30	To Profit and Loss	5	5	06	08
		£		50	06	08

1814		*James Aldworth* Dr.	Fo.	£	S.	D.
March	9	To Sugar	2	492	16	00

1814		*Thomas Ellis* Dr.	Fo.	£	S.	D.
March	12	To Linen	3	100	00	00

1814		*Muslin* Dr.	Fo.	£	S.	D.
March	15	To Sundries, 42 pieces, each 15 yards, at 3s. 10½d. per yard		122	01	03
April	30	To Profit and Loss	5	24	16	03
		£		146	17	06

1814		*Robert Turner* Dr.	Fo.	£	S.	D.
April	6	To Cloth	2	97	18	04
		£		97	18	04

LEDGER. (4)

1814		CONTRA Cr.	Fo.	£	S.	D.
April	18	By David Hawkins, 40 gallons, at £1..0..8d	6	41	06	08
	30	By Balance, 10 gallons remaining at 18s.	6	9	00	00
		£		50	06	08

1814		*Contra* Cr.	Fo.	£	S.	D.
April	25	By Sundries, as per journal		492	16	00

1814		*Contra* Cr.	Fo.	£	S.	D.
March	21	By Bills receivable	2	100	00	00

1814		*Contra* Cr.	Fo.	£	S.	D.
April	4	By Cash, 16 pieces, at £3..13..6 per piece	1	58	16	00
	14	By William Herbert, 14 pieces, at £3..16	3	53	04	00
	30	By Balance, 12 pieces on hand, at 3s. 10½d. per yard.	6	34	17	06
		£		146	17	06

1814		*Contra* Cr.	Fo.	£	S.	D.
March	15	By Muslin	4	70	00	00
April	30	By Balance		27	18	04
		£		97	18	04

(5) LEDGER.

			Fo.	£	S.	D.
1814		GEORGE FANSHAW Dr.				
March	18	To Sundries, as per journal		443	17	00
		£		443	17	00
1814		*Commission* *Dr.*				
April	30	To Profit and Loss	5	25	02	11½
		£		25	02	11½
1814		*Profit and Loss* *Dr.*				
April	2	To Cash for rent and other charges	1	35	15	00
	8	To Cash for a bank note lost	1	10	00	00
	25	To James Aldworth	4	172	09	04
	30	To Cash for expences	1	33	12	09
		To Stock gained	1	101	11	09½
		£		353	08	10½
1814		*Merchandise* *Dr.*				
April	2	To Rowland Hill as per Journal	5	296	11	00
		£		296	11	00
1814		*Rowland Hill* *Dr.*				
April	30	To Balance	6	296	11	00
		£		296	11	00

LEDGER. (5)

1814		CONTRA CR.	Fo.	£	S.	D.
March	18	By Sundries, as per journal		243	17	00
April	30	By Balance	6	200	00	00
		£		443	17	00
1814		*Contra* *Cr.*				
March	28	By Cash	1	7	10	00
April	2	By Walter Barnard	6	7	16	11½
	11	By Sales per Mary	6	9	16	00
		£		25	02	11½
1814		*Contra* *Cr.*				
March	31	By Cash for a legacy	1	100	00	00
April	30	By Cloth, gained	2	43	15	00
	—	By Sugar, do.	2	106	08	00
	—	By Linen, do.	3	48	00	00
	—	By Rum, do.	4	5	06	08
	—	By Muslin, do.	4	24	16	03
	—	By Commission, do.	5	25	02	11½
		£		353	08	10½
1814		*Contra* *Cr.*				
April	2	By Walter Barnard	6	296	11	00
		£		296	11	00
1814		*Contra* *Cr.*				
April	2	By Merchandise, as per journal	5	296	11	00
		£		296	11	00

(6) LEDGER.

			Fo.	£	S.	D.
1814		WALTER BARNARD Dr.				
April	2	To Sundries, as per journal		321	15	07½
	30	To Balance	6	42	14	04½
		£		364	10	00
1814		*Sales per the Mary* *Dr.*				
April	11	To Sundries, as per journal		392	00	00
1814		*David Hawkins* *Dr.*				
April	18	To Rum	4	41	06	08
		£		41	06	08
1814		*Interest* *Dr.*				
April	30	To Balance	6	2	00	03
		£		2	00	03
1814		*Balance* *Dr.*				
April	30	To Cash	1	758	09	11
		To Bills receivable	2	495	00	00
		To Thomas Brown	3	5	00	00
		To William Herbert	3	40	00	00
		To Rum	4	9	00	00
		To Muslin	4	34	17	06
		To Robert Turner	4	27	18	04
		To George Fanshaw	5	200	00	00
		To David Hawkins	6	41	06	08
		£		1611	12	05

Ledger. (6)

1814		Contra Cr.	Fo.	£	S.	D.
April	11	By Sales per Mary	6	364	10	00
		£		364	10	00
1814		*Contra* *Cr.*				
April	11	By Sundries, as per journal		392	00	00
1814		*Contra* *Cr.*				
April	30	By Balance	6	41	06	08
		£		41	06	08
1814		*Contra* *Cr.*				
April	20	By Bills payable, for discount	3	2	00	03
		£		2	00	03
1814		*Contra* *Cr.*				
April	30	By Rowland Hill	5	296	11	00
		By Walter Barnard	6	42	14	04½
		By Interest	6	2	00	03
		By Stock	1	1270	06	09½
		£		1611	06	09½

The waste-book opens with an account of the merchant's effects in business or trade, and of his debts to other persons. The first set of articles exhibit his stock; and each article is entered in the journal as Dr. to stock for its value or amount; while on the other hand, stock is said to be Dr. to each article in which money is due from the trader.

The first transaction of the 4th of March, in which cloth is sold for ready money appears in the journal in this way, cash Dr. to cloth, that is, cash received is accountable for cloth given away: but in the second transaction of the 7th of March, linen is bought for ready money; linen is therefore entered in the journal as Dr. or accountable to cash for the money paid for it.

On the 9th, Thomas Brown supplies rum on credit: the rum is therefore accountable to him for its value, and is consequently journalised as Dr. to Thomas Brown.

On the 12th, linen is parted with to Thomas Ellis: of the price a portion is received in ready money, and the remainder is upon credit. In this case the journal must exhibit two Drs. viz. cash Dr. to linen for the money paid down, and Thomas Ellis Dr. for the remainder at a fixed period mentioned in the waste-book.

On the 28th, the merchant gains a sum of money for his trouble in receiving and transmitting money on account of Richard Wilson. Here no real value on effects pass from the merchant; a fictitious account is therefore formed, entitled commission, under which are to be entered all articles of this sort, whether received or paid by the trader.

On the 31st, a legacy is received, which being regarded as pure gain, for which no equivalent is given, another fictitious account is opened, with the title of profit and loss, to which cash is Dr. for the amount of the legacy.

On the 2nd of April several charges are paid, such as rent, &c. all necessary in conducting business, but for which no real value is received by the merchant: to the same account of profit and loss, or to some similar fictitious account these articles must therefore be charged.

In this manner by applying the several rules formerly given, the method of transferring accounts from the waste-book to the journal may be readily understood; and the following step or the carrying of the same accounts from the journal to the ledger will be very simple.

The ledger opens, in the first folio, with an account for stock, on the Dr. side of which is entered the amount of the several articles of what the merchant owes, and on the Cr. side the amount of the articles composing his effects or estate in trade. The next account opened is for cash, which is the first article in his account of effects: cash being made Dr. to stock for the ready money in his hands. Then comes the account for bills receivable which, in the same manner, appear Dr. to stock for the bill on Philip Hawkins. This is followed by the account of cloth which is charged as Dr. to stock for the number of pieces and yards, at a given price. The next account is for sugar, stated to be Dr. to stock for the

quantity on hand when business is commenced; and on the other side Cr. by each separate quantity disposed of at different times. Lastly appears the account of Thomas Brown, as Dr. to stock for the amount of his debt to the merchant.

All the articles composing the merchant's stock in trade being thus entered, or posted as it is called, in the ledger, those constituting his debts are next to be posted. In this process however is this difference, that as the former were all Drs. to stock, so the latter are all Crs. by stock, that is stock is charged as Dr. to each article for its amount. The account of William Herbert is therefore stated Cr. by stock for the debt to him, as is that of bills payable for the value of David Murray's bill accepted by the merchant.

The sale of cloth for ready money on the 4th of March is posted in the ledger, from the journal, cash Dr. to cloth for the value received; and cloth is charged Cr. by cash for the quantity sold as well as the value. This is the process styled double entry: and by comparing the several articles in the waste-book, journal, and ledger, the young book-keeper may learn how to transfer any other transaction from one book to another.

The crooked line or dash in the column on the left hand of the waste-book, opposite to each account, shows that those accounts have been journalised: and the numbers in the left hand column of the journal indicate the folios of the ledger where the several articles of any account are posted. When two numbers appear, one immediately above the other, they express that in the opposite line of the journal are two articles, each of which is entered in the ledger. Thus in the transaction of the 4th of March, both cash and cloth have accounts in the ledger: cash being the first in order is represented by the upper number 1, because that account is in the first folio; while cloth the second in order is indicated by the lower number 2, because the account of cloth is in the 2nd folio. In the ledger is a column immediately preceding the money columns, in which is marked the folio of the account specified in the entry. Thus in the cash account, opposite to the article cloth of the 4th of March, the number 2 appears, because the cloth account is in the 2nd folio: and on the other hand, in the cloth account, opposite to the same date the number 1 appears, because the cash account is in the 1st folio.

To ascertain the accuracy of the books it is necessary, at certain periods, to make what is termed a trial balance of the ledger. This is founded on this principle that, as every account of the journal is twice posted in the ledger, in one account on the Dr. side, and in another on the Cr. side, it is evident that the sum of all the Drs. should be precisely equal to the sum of all the Crs. When therefore the sum of all the articles on the Dr. side are precisely equal to the sum of all those on the Cr. side, then the books are supposed to be free from error. To form the general balance however more is requisite, because each separate account must be balanced by itself: observing always that the accounts of stock and profit and loss cannot be balanced until all the other accounts are closed.

To begin with the cash account, in folio 1 of the ledger, the Dr. and Cr. sides being summed up, and the less subtracted from the greater, the difference is placed on the less side, to balance it, or make it even with the greater. Thus in the specimen before given, the amount of the Dr. side of the cash account is £1479..00..04; but that of the Cr. side is only £720..10..5: the difference between these sums £758..09..11 must therefore be placed in the Cr. side of the account charged by balance, which will make the two sides equal and even. The same thing would be done in the next account for bills receivable: but there all the articles being on the Dr. side, their whole amount must be placed as a balance on the Cr. side, to make both even. In the cloth account the whole quantity being sold at a price higher than what was given for it, the Cr. side will exceed the Dr.: in this case the difference, representing the money gained upon the merchandise, must be entered on the Dr. side and charged to the fictitious account of profit and loss. Had the Cr. side been the least, and consequently had the goods been sold for less than they cost, owing perhaps to some accident or defect in the quality of the cloth, a loss must have been sustained, the difference between the two sides of the account must have been placed in the Cr. side to make it equal with the Dr. side; and cloth would have become Cr. on profit and loss for the deficiency. Of this we have an example in the transaction of the 25th of April, where James Aldworth becoming insolvent, a loss is sustained by the merchant's being obliged to compound his demand, by which he received only thirteen shillings for every twenty shillings that were due to him. The whole sum due by Aldworth was £492..16..00, which at the rate of 13s. in the pound will be reduced to 320..06..08; the difference £172..09..04 must therefore be charged on the Dr. side of profit and loss, as the loss sustained by the merchant on the transaction.

When all the accounts on which there has been either gain or loss are summed up, and the several sums are entered in the proper sides of the account of profit and loss, the difference between those sides is carried into the stock account in the ledger, in this way. If the Cr. side be the greatest, then the merchant has gained, because his credits exceed his debts, and his stock when the transactions are concluded is greater than when they were commenced: stock is therefore become Cr. by profit and loss for the amount. On the other hand, had the Dr. side been the greatest, then the merchant would have appeared to be a loser on the whole of his business, and stock would have been charged as Dr. for the amount, or the merchant's stock in trade would have been by so much less than it was when he began business. But as in the foregoing example of mercantile books, supposing the trader to be upon the whole a gainer, profit and loss must be charged as Dr. to stock for the amount of his gains upon the transactions of two months, viz. £101..11..09½. This being entered in the Cr. side of the stock account will, together with the other articles composing the whole of his effects, make a certain sum, from which subtracting the amount of the Dr. side, the

difference or balance £1270..06..09½ is the value of his effects when he closed his books: and the same sum being entered in the Cr. side of the balance account ought, if no error be committed in the keeping or the casting of the accounts, to make that side equal and even with the Dr. side.

In conducting large and complicated mercantile concerns, many accounts in the ledger must be simplified and shortened, by employing sundry assisting or subsidiary books, each set apart for particular branches of business. Of these the principal are the Cash book, the Bill book, the Sales book, the Invoice book, &c. forming so many parts of the waste-book, for those articles belonging to the respective subject of each subsidiary book. By this method the proper waste-book will comprise only a general statement of transactions noticed in the subsidiary books; with particular specifications of those transactions alone for which no other books are kept. By this process, and by balancing those smaller books at stated periods, monthly or otherwise, the entries in the ledger are greatly diminished in number. Persons employed to import or export goods on commission, or for the account of others, must at all times keep books of Invoice and Sale: and Cash and Bill books are indispensible in every branch of mercantile concerns.

The cash book contains an account of all money matters, kept in the same way with the cash account in the foregoing specimen of a ledger; the Dr. side showing all monies received, and the Cr. side all monies paid or expended. This book contains all such issues or receipts of money as being merely temporary, like small loans, occasional accommodations to neighbours in trade, &c. need not appear formally in the regular journal and ledger.

The Bill book exhibits a register of all bills of exchange, both payable and receivable: it is divided into columns set apart for the several particulars relative to each bill, such as when received, by whom drawn, on whom drawn, the date, to whom payable, the time when due, the sum, &c. &c.

The Invoice book contains copies of all invoices or statements of goods sent off or exported, on commission; containing the name of the ship and the master; the place of destination, the person to whom the goods are consigned. Then follows a statement of the quantities and values of the several articles dispatched, and of the charges for shipping the goods or for other purposes, paid by the merchant, the exporter, or the factor. Upon the total amount of all these expenditures is charged the commission or allowance for the trouble of the exporter. Thus in the specimen of books before given, on the 2nd of April, callico, cotton, and wine, to the value of £206..11, were purchased and exported. The expences of of shipping these goods and other charges came to £17..07..08, which, added to the value of the goods, made £313..18..8. The commission or demand of the exporter for his care and trouble was made at the rate of £2..10 on every £100, or at 2½ per cent. on this last sum, amounting to £7..16..11½; consequently the whole

sum due to the exporter will be £321..15..07½, as entered in the money columns.

The Sales book or factory book points out the neat or (as it is usually written) the net proceeds, or the exact money arising from the sale of any article or merchandise, when all expences are deducted, and when that sale has been made upon consignment or commission. This is also called the account of sales, or more commonly account sales; and it is divided like the accounts in the ledger, into two opposite pages forming one folio, with the title extending across both. On the left hand are entered all charges attending the transaction, such as those for freight, customhouse dues, landing, warehousing, selling, &c. On the same side appear also the broker's charges and the factor's commission, both of which are reckoned up in the gross or total amount of the sales. On the right hand page appear the quantity, the price, the value of the goods sold, with the name of the buyer, and the mode and time of payment. When the total expenses of the transaction are taken from the total amount of the sales, the difference is called the net proceeds, which being entered on the left hand page makes it equal to the other on the right. For this amount of net proceeds the factor gives his correspondent credit; transmitting to him a copy of the account sales, signed with his name, and certified to be correct, *errors excepted.*

Bills of Exchange.

Exchange means the paying of a sum of money in one country, or in one place of a country, for an equivalent sum in another country, or in another place of the same country. This is done by means of Bills of Exchange, which are written orders directing the payment of a certain sum of money at a fixed time. Bills of exchange are either inland or foreign: the former are drawn and payable within one and the same state or country: but foreign bills are drawn in one country or state and payable in another.

The person who writes or draws the bill is called the *drawer*, the person on whom it is drawn or to whom it is addressed is the *drawee*, and also the *acceptor* as soon as he engages to pay the bill, and he to whom the money is to be paid is the *payee*. Besides these persons others are frequently concerned in bills of exchange, such as the buyer or remitter, the seller or negotiator, and the possessor or holder of the bill.

When a holder parts with a bill he indorses it, that is he writes his name on the back; and thus every indorser becomes liable or a security for the payment. The first indorser ought to be the payee who, by a special indorsement, may direct the payment to be made to a third person not named in the bill, who thus becomes the *indorsee*. When a bill is presented to the drawee and accepted by him, he writes his name at the bottom, with the word *accepted*; but if the acceptance be refused by the drawee the bill is put into the hands of a notary public, who causes it to be noted for non-

acceptance. If a bill which has been accepted be refused for payment when due, it is also noted or protested and returned to the drawer who, or any one of the indorsers, is then liable to pay the value of the bill, with all expences incurred in the business. It is necessary to take care that no time be lost in returning a protested bill, otherwise the holder can have no claim for payment on any person concerned in it but on him who accepted it.

The period when a bill is due, or its *term*, varies according to the agreement between the parties concerned, or to the custom of the countries where it is drawn and made payable. Some are drawn at sight, that is they must be paid as soon as presented: others are made payable at a certain distance of time, as a number of days after sight, or after the date of the bill: others again are drawn at *usance* which is the customary term allowed, in different countries for a bill's being paid after it is dated, or presented for payment. Double usance is twice this term, and half usance is half this term.

Besides this usual term of payment a certain time is also allowed, after the term is expired, before payment can be inforced by law; and this additional time consists of a certain number of *days of grace* or favour, which in the British isles, is three: but bills drawn at sight are not entitled to any indulgence or days of grace.

In exchanges two things are principally of importance, the *par* and the *course* of the exchange. The par signifies the equality or the precise proportion between coins of different states, or the real value of the coin of one country in coin of another. The course of exchange means the current value of coins as established in practise between two countries. Were the coins of different states subject to no alteration in respect of their several intrinsic proportions in weight and quality of metal, the par would be easily ascertained: but as this is by no means the case, the par of exchange must be liable to frequent fluctuations.

By bills of exchange debts may be reciprocally discharged in different places, without any real transmission of coin: thus if Edward at York owe fifty pounds to Robert of Bristol, and Thomas of Bristol owe Richard of York an equal sum of fifty pounds, the debts may be mutually transferred and discharged in this way. Robert draws a bill on Edward which Thomas purchases by paying its full value, and transmits it to his creditor at York Richard, who presents it to Edward the debtor of Robert of Bristol, by whom the money is paid.

When the debts reciprocally owing between two places are of unequal amount, the difference must be remitted in money or bills: but on account of the inconvenience and risk attending remittances in specie or coin, bills are the most convenient means of payment. When many bills are required for remittance to any place, the number of purchasers will be increased, and consequently the price of such bills will be enhanced; that is, the course of exchange will be raised in favour of the place to which the bills are to be remitted. Hence it is that London enjoys the advantage of

exchange over every other place in the united kingdom. So great is the amount of the debts owing from Dublin the capital of Ireland to London, when compared with that of the debts owing from London to Dublin, that a person in Dublin must give £108, or £109 for a bill of 100 payable in London, and a London bill of £100 will in Dublin be worth £108, or £109. The usual course of exchange therefore, between these two capitals, is generally about 8½ per cent. in favour of London, which is no less than one twelfth part of any given sum. Between London and Edinburgh the capital of Scotland, the commercial intercourse, and consequently the course of exchange is much more nearly balanced, so that it fluctuates between 3 and 4 per cent.: a bill therefore of £100 payable in London, may at Edinburgh be obtained for £103 or £104.

Hence may be seen how the fluctuation of the course of exchange, between any two places, must in general be proportioned to, and regulated by, the balance of debts or remittances between them; and this balance is again produced by the balance of trade, or the difference between the values of the exports and imports of both places relatively to each other. Thus if London export goods to Lisbon to the value of £1000, and import from Lisbon goods to the value of £1500, the difference of value and consequently the balance of trade is evidently against London, and in favour of Lisbon. If London remit this balance in bills of exchange, the price of such bills in the market must rise, and of course more money must be given in London, to procure the payment of any given sum in Lisbon, than would be expressed by valuing these sums at the par or just value of the coins of each country. On this account when the course of exchange runs high against any country, remittances from it ought, if possible, to be made in coin instead if bills, which will tend to reduce the rate of exchange nearer to par.

Exchanges are calculated by the rule of Practice in arithmetic. Thus if it be required to find the value of £500 sterling in French money at par of 24 *livres* or *francs* for the pound sterling, the product of 500 multiplied by 24, or 12,000 *livres* is the anwer. At the par of 24½, or 24 *livres* 10 *sous*, the same sum of sterling would be worth 12,250 *livres* French.

Of Banks.

Banks, the main support and channel of modern commerce, are either public or private: public banks are established by a number of persons incorporated by charter, who contribute a fund for the purposes of the society: private banks are established by persons not chartered, who conduct their business on their own capital and credit. Private banks are farther distinguished into London banking houses and country banks. A *London banking house* is a place where persons, for the sake of security, and other reasons, keep money rather than in their own houses. When an account is opened in such a house, that is, when a person pays

in money, to be drawn out as may be necessary, he is furnished with a *customer's book;* on the left hand page the house is entered Dr. for the sum paid in, and on the right, it is Cr. for the sums he draws out. In this book the customer never writes himself: but what he pays in is entered by the banker or his clerk, which serves as a receipt; and when the customer wishes to know the state of his account at the bankers, or to compare it with his own private note of monies drawn, he gives in his book to be *written up* or settled. The books generally used in a banking house are the *money-book,* in which the cashier enters his receipts and payments of money; the *waste-book* in which both money and paper, received and paid, are particularly specified: in some houses however, a book is kept for paper only, called the *goldsmith's-book.* The *cash-book* follows, containing all the sums of both money and paper paid and received. From this book the *ledger* is posted, in which each customer is debited for the sums he has drawn out, and credited for those he has paid in. The *custommer's-book* is written up from his drafts paid and cancelled, and checked by the account in the *ledger.* Besides these books bankers keep others as the *in bill-book,* for bills paid in by customers; the *out bill-book,* for bills sent out for acceptance or payment; the *check bill-book,* for bills to be brought together, that become due on the same day; and the *discount bill-book,* for all bills discounted: a *discount ledger* is also kept, to show the state of every discount operation. When to this variety of books are added the daily, yearly, and other balances, a banker seems to possess every possible means for proving and checking his accounts, so that with common care no disorder can ever ensue.

The advantages arising to the London banker (who gives no interest for money placed in his hands for a temporary purpose) chiefly consist in laying out part of the money on good securities, such as in the stocks or other government paper; and in discounting bills, by which the most essential support is afforded to trade and commerce. Besides this, bankers are of great use to merchants, by undertaking the management of their bills, and other receipts and payments, by which the business of the counting-house is materially lessened: and this important branch of business is conducted without any charge, and with the strictest accuracy. *Country bankers* also take charge of other men's money, discount bills, &c.: but in other respects they differ from London bankers. Some country bankers pay interest for money placed with them, on condition of receiving certain notice before it be drawn out: others keep a neutral interest account and charge a commission on their payments. Country bankers also issue their own notes (which is not done in London) payable to bearer on demand; most of them being made payable at some London house where the country banker keeps an account, like that of any other private customer.

The *Bank of England,* in principles and operations, is similar to private banks: it takes charge of money; discounts bills; it likewise issues its own notes; it also acts as banker and agent for

government, in receiving revenues and paying dividends of stocks and other public debts: it also deals in gold and silver and foreign coins. An account is opened with the bank, in the same way as with a private banker, except that in it no *cash account* is begun with less than £500; nor any *discount account* opened but by the approbation of the court of directors, and every bill discounted or cashed must have on it two approved names, at least of persons residing in or near London. The bank of England was founded in 1693, in the reign of king William, about the time that our present enormous national debt began to be contracted: the proprietors were incorporated, and on account of that charter, the capital, now twelve millions, has been lent to government at a low interest. The business is under the management of a governor, deputy governor, and twenty-four directors, annually chosen from among the proprietors; and the qualification of a proprietor to vote is, to have been possessed of £500 bank stock, for six months previous to the time of voting.

In *England* there is one great national bank, with about seventy banking houses in London, and four hundred in the country. By the joint operation of this system of banks the trade and commerce of the nation is carried on, and ultimately almost always in the paper of the bank of England. For since the bank was restricted from paying in specie, its paper, though not made absolutely a legal tender (that is, though no man can be absolutely compelled to accept it as payment in the place of coin,) answers all the purposes of cash, and is so called in the books of bankers and merchants.

Scotland contains two public banks, the *bank of Scotland*, and *the Royal bank*, with many private banks, all nearly on the same principle of English country banks.

Ireland possess one public bank, the *bank of Ireland*, and many private banks, similar to those above described.

Foreign banks, such as those of Amsterdam, Berlin, Copenhagen, Hamburgh, Venice, Vienna, &c. are called *banks of deposit;* because the money placed in them is sunk, and never drawn out, but transferred in payments, from one person to another, like stock in the funds of this country. Much of the business of foreign bankers, consists in drawing, negotiating, and discounting bills of exchange.

Explanation of the most common terms employed in commercial transactions.

Acceptance, the act of accepting a bill of exchange by which the acceptor or drawee makes himself liable to pay it when due.

Accommodation is a term employed when the drawee accepts a bill, by only lending his name to accommodate and oblige the drawer of the bill who engages to furnish the accepter with the means of paying the bill before it become due.

Administrator, *Administratrix*, a man or a woman who, by certain forms in the ecclesiastical courts, is authorised to take the charge of the personal property of a person who dies without making a will.

Arbitration, a mode of settling a dispute, by referring the question to the decision of one person or more, without carrying the matter into a court of law.

Arbitration of Exchange is a comparison made between the state of exchanges at different places, in order to draw or negotiate bills to advantage.

Assurance, the same with *Insurance*, which see;

Assignee, a person appointed to manage the affairs of a bankrupt.

Attachment, the act by which a creditor may claim and seize the goods of his debtor, in whatever hands he finds them.

Average, a contribution made for losses at sea, and is divided into general and particular, or gross and simple. General average is a proportional contribution paid by all the proprietors of a ship and cargo, for losses incurred in the view of safety, such as throwing goods overboard, cutting away masts, &c. to lighten the vessel and prevent shipwreck. Particular average is a contribution to such damages or losses as happen from the common accidents of the sea; where the average is borne by the proprietors of those articles only which are damaged. Averages, like other cases of loss or gain, are computed by the common rule of Fellowship. (See arithmetic.)

Balance the difference between the Dr. and Cr. sides of an account.

Balance of trade, the difference between the commercial exports and imports of one country when compared with those of another with which it trades.

Bankrupt, a person in some trade who cannot make good his payments, and who has therefore a commission of bankruptcy taken out against him, (see Commission.)

Barratry, a fraud committed by the master or the crew of a ship, on the owners or insurers; such as sinking, deserting, or taking away the ship, or plundering the cargo.

Barter, the exchanging or trucking of one commodity for another.

Bill (Bank) a note signed by a cashier of the bank, promising to pay a certain sum of money, at an appointed time; in which particular it differs from a bank note, which is payable on demand.

Bills of Exchange, written orders for the payment of money.

Bills of Exchequer, securities issued by government, which bear interest until paid off. These bills are mostly for £100 each, and the interest is 3 pence per day, a little better than 4½ per cent.: but some are for £1000, which bear interest at 3½ pence per day, or nearly 5½ per cent.

Bills (India) are drawn in India on the Company in London, and made payable at the India House.

Bills of Lading, are papers signed by the master of a ship, acknowledging the receipt of certain goods on board his vessel, and promising to deliver them at some appointed place. It is usual to make out three bills of lading, of which one is left with the shipper of the goods, the second is kept by the master of the

2 D

ship, and the third is dispatched to the persons to whom the goods are sent, that he may claim them on their arrival.

Bills (Navy) are issued by the Navy Board in London, in payment of stores for the ships, dock-yards, &c.; being payable at 90 days, with interest of 3½ pence per day per cent. Similar bills are also issued by the Victualling Board.

Bills of Parcels contain the particulars of goods bought, and are given by the seller to the buyer.

Bill of Sale is a deed by which a right or interest in certain goods is transferred from the seller to the buyer.

Bonds (India) are issued by the East India Company, of £50 and £100 each, bearing interest at 5 per cent. which interest is paid at the India House.

Bottomry is a contract or loan on a ship, in the nature of a mortgage: but it differs from other mortgages or loans, inasmuch as the interest is much higher, because the security for the payment is very precarious; for if the ship be lost, neither principal nor interest of the loan can be demanded.

Brokers, persons appointed to transact business of various kinds between merchants and others: thus we have exchange brokers, insurance brokers, ship brokers, stock brokers, &c.

Charter Party is a contract executed between the person who hires a ship and the owner, setting forth the terms, &c. A ship is said to be chartered when she is hired for a voyage.

Cloff or Clough, an allowance in the weight of goods, after deducting the tare and tret; it is generally of 2 pound for every 3cwt.

Cocket, a warrant from the custom-house, given on the entry of goods, to show that they have paid the duties.

Commission, a per-centage, or allowance of so much on every £100, granted to agents, factors, &c. for transacting the business of their employers.

Commission of Bankruptcy, is an order from the Lord Chancellor, under the great seal, directing five or more commissioners to inquire into the affairs of a bankrupt.

Composition, part of a debt taken in place of the whole, by which it is entirely discharged.

Contraband Trade, that which is forbidden by law.

Convoy, ships of war sailing with merchant ships to protect them against an enemy: it is also used, but improperly, for the ships protected.

Countervailing Duties (called by the French *Droits de balance*) are equal duties established between two countries, and charged on the exportation and importation of the same kind of goods.

Currency, the *money* in circulation, as distinguished from bank paper: but in North America and the West Indies, the *paper* in circulation is called currency to distinguish it from sterling.

Days of Grace, a certain number of days allowed, after the term of a bill is expired, before payment can be exacted. This allowance is different in different countries: in Britain and Ireland it is three days.

Debenture, a certificate given at the custom-house, when the exporter of goods conforms to the proper regulations, by which he is entitled to receive a bounty or drawback.

Demurrage, an allowance to the master of a ship, for being detained in a port beyond the time agreed on.

Discount, an allowance made for prompt payment, or for taking up and discharging an accepted bill before it be due.

Dividend, a share of any profit, debt, or capital, also the interest of the public stocks.

Docket, a short memorandum or summary affixed to larger papers. *Striking a docket* is when a creditor gives bond to the Lord Chancellor, proving his debtor to be a bankrupt.

Drawback, an allowance or premium for the exportation of goods. (See *Debenture.*)

Embargo, the stopping of ships, by the order of the government of a country.

Exchequer, the court to which all revenues belonging to the crown are brought, and all causes relative thereto are tried.

Excise, an inland tax upon commodities, as is *Custom*, upon goods imported or exported.

Factor, a merchant's correspondent or agent in some distant or foreign part.

Factory, the name of a commercial establishment in a foreign country, as at Aleppo and Smyrna in Turkey, where factors, merchants, and traders carry on business with the natives of the country.

Finances, a French term, signifying means of subsistence, but in England generally applied to the public revenue of the state.

Firm, the title or names employed in the signature of a mercantile, or banking house, or company.

Forestalling, the buying up of goods, &c. before they come to the market, in the view of selling them again at an advanced price.

Funds (Public) See *Stocks*.

Gross, twelve dozen. *Gross weight* is the whole weight of goods, including chests, bags, dust, &c. &c.

Indorsement. When the holder of a bill disposes of it, he writes his name on the back, that is, he indorses it, and every indorser becomes a security for the payment. The *payee*, or he to whom the bill is made payable, ought to be the first indorser.

Instalments, payments of a sum of money in certain proportions, and at stipulated times.

Insurance, also called *Assurance*, is a contract of indemnity by which one party engages, for a certain sum, to insure another against a certain risk specified in the contract. The party taking upon him to indemnify the other is called the *insurer*, *assurer*, or *underwriter*; and the party protected is called the *insured*: the sum paid to the insurer is the *premium* or reward; and the paper or parchment containing the contract is called the *policy*.

Ingrossing, buying up large quantities of corn or other provisions, for the purpose of keeping them from the market and reselling them at a higher price.

Invoice, a paper sent off with goods exported on commission, containing the names of the ship and the master, of the place of destination and of the person to whom the goods are sent. An account is then given of the quantity and value of the goods at prime cost, to which are added the charges of shipping, and upon this total sum the agent or factor charges his commission.

Inventory, a list or schedule of effects.

Key, kay, or quay, a lawful wharf, or place on a river or harbour for landing and shipping goods.

Leakage, an allowance made at the custom-house, for waste or loss of liquors.

Letter of Advice, a letter giving notice of any transaction in mercantile affairs:—a letter or power of attorney is a writing by which one person is empowered to act for another:—a letter of credit, by which one person is authorised to receive money, on the credit of the writer:—a letter patent is a privilege granted by the king to an inventor, to enable him exclusively to reap the advantages resulting from his invention, for a certain number of years, after which the invention becomes public:—letters of marque are commissions granted to captains of ships and others, in time of war, to make reprisals on the ships of the enemy.

Lien, a law term, signifying a claim or attachment on any property, which a person has in his possession, for a debt due to him by the owner of that property.

Liquidation is the concluding or winding up of a business, such as paying and receiving all debts, &c.

Loan, any thing given to another for his use, but to be restored to the owner: in public business a loan means money lent to government, which makes part of the national debt.

Manifest, a paper containing the particulars of a ship and cargo, which must be signed by the master of the vessel, before any goods can be landed.

Mart, a great market, fair, staple, or other place of public traffic.

Maximum and minimum, two Latin terms expressing the *highest* and *lowest* prices of any article, as fixed by some law or regulation.

Mortgage, lands, houses, goods, &c. pledged as a security for money borrowed. The borrower is called the mortgager, and the lender the mortgagee.

Neat or net weight, what any goods weigh alone, without the cask, package, dross, &c.

Neat Proceeds, the amount of goods sold, after every necessary deduction for charges &c. is made.

Nonclaim, when a creditor neglects to make his claim upon a debtor's effects, within a proper time, by which neglect he cannot enforce the payment of his demand.

Notary Public, a person duly appointed to attest deeds and other writings; also to note and protest bills of exchange, draughts, notes, &c. when refused or returned unpaid. *Noting* is the act of the notary, when a bill is not duly honoured.

Omnium, see *Stocks*.

Par of Exchange is the real intrinsic value of the coin of one country, when compared with the coin of another, with respect to the weight and the fineness of the metals. By fineness is understood the proportion of pure gold or silver to the baser metal or alloy mixed in the coin. In England the standard fineness of gold coin is 22 carats of pure gold to 2 carats of copper, the carat being the 24th part of the weight. The standard for silver is 11 ounces 2dwts. of pure silver to 18dwts. of copper, making together one pound troy. These standards it is supposed were fixed in the reign of Richard I. six hundred years ago, by persons from Germany, thence called here *Easterlings*: and from them we have the word *sterling* to denote the lawful money of Britain.

Permit, a licence or warrant for the passing from one place to another, or the selling of goods which have paid custom or excise duties.

Protest, a paper by a notary-public declaring a certain bill to have been refused.

Quarantine, or rather *quarantaine*, the number of days (in general *forty* whence the name,) that a ship suspected of infection, or coming from a suspected quarter, is obliged to keep from all intercourse with the country where she arrives; to see whether or not she be really infected with the plague: also certain duties imposed on ships, for the purposes of quarantine.

Regrating, buying and selling again with profit, in the same market, of corn or any other provisions.

Respondentia, a bond or contract by which money is borrowed on the security of goods, as in bottomry on the security of a ship.

Salvage, an allowance made for saving ships or goods from danger of seas, enemies, &c.

Sea-worthy is when a ship is, in every respect, fitted for her destined voyage.

Stock, a fund raised by a commercial company; a principal or property employed in trade: in book-keeping stock denotes the owner or owners of the books.

Stocks, or Pulic Funds, are the debts of government, for which interest is paid from revenues set apart for the purpose. The mode of raising supplies for the state, by borrowing, and levying taxes to pay the interest, is called the *funding system;* and loans thus raised constitute the *national debt*. Government debts differ from other contracts in this, that the creditor or stock-holder can only claim his interest: but he may sell his stock, and so obtain his capital. Loans are generally raised on interest, and are thence called *perpetual annuities;* and are redeemable, because government may pay off the principal whenever it is at par. The different funds are distinguished according to the rate of interest they bear: thus we have the three per cents. the four per cents. the five per cents. In buying stock a specific is given for a nominal sum: if for instance the price of the three per cents. be at 60, by paying £60 we obtain £100 of that stock, which yields £3 per

annum, being just 5 per cent. When the four per cents. are at 80, and the five per cents. at 100, the same interest of 5 per cent. will be obtained by purchasing at these prices. New loans are generally paid in by instalments of 10 or 15 per cent. at stated periods, and in different kinds of stock, thence called *Omnium*. If these be disposed of separately, before the instalments are paid, the different articles are called *Scrip*. When taxes are set apart for paying the interest of a loan the debt is then said to be *funded*: but when no such provision is made, the debt is *unfunded*. Of this last description are exchequer, navy, victualling, and ordnance bills. The term stock is also applied to the capitals of the Bank of England, of the East India, and South-sea companies, &c.

Tally, a cleft piece of wood on which an account is scored. Tallies are still used by the officers of the court of exchequer, who keep one of the clefts in the office, and give the other to those who pay in money upon loan, and other accounts.

Tariff, a foreign word signifying a table or account of the rates of duties laid upon merchandise.

Tontine is a loan raised on life annuities, with the benefit of survivorship. Thus an annuity, after a certain rate of interest, is granted to a number of subscribers, who are divided into classes, according to their ages; and annually the whole fund of each class is shared among the survivors, till at last the whole falls to one; and on the death of this last survivor it returns to the power that first established the tontine. The term is borrowed from the name of the inventor.

Ullage, what a cask of liquor wants of being full.

Umpire, a person appointed to settle a dispute or difference, when the arbitrators originally chosen cannot agree.

Underwriter, a person who insures ships, cargoes, or other things exposed to risk, which is done by writing his name, with the sum for which he engages, under a policy of insurance.

Usance, the usual term of bills of enchange, on certain places, such as one, two, or three months after date: double or half usance means double or half the ususal time.

Usury, a charge of interest beyond what is allowed by law. In Britain the legal interest of money is 5 per cent. In the West Indies it is 6 per cent.

Warehoused goods, or Bonded goods, certain articles which, on being landed, are suffered to be placed in the warehouse, upon a bond being given by the owner, for the payment of duties, &c.; after which they may be sold and removed.

Wharfage, a certain rate paid for the use of a wharf, for shipping or landing goods.

It was formerly mentioned that, in conducting mercantile business on an extended plan, other books besides the waste-book, journal, and ledger, are requisite; those were stated to be the cash-book, the bill-book, the sales-book, the invoice-book, and the like. That the young merchant may have some idea of these subsidiary or assisting books, the following specimens will perhaps be sufficient.

The *cash book* is ruled and filled up precisely like the cash

account in folio 1 of the foregoing ledger, without however the column for folios: and in carrying the transactions, as they there appear, into the journal, once every week or rather every month, it is customary to class in succession to each other, according to dates, all occurrences coming under the same general description; examples of the cash-book seem therefore unnecessary.

The *bill-book* contains a record of all bills of exchange in which the merchant is interested, whether payable or receivable. Bills payable are such as are drawn upon him, and which he must pay when due: and bills receivable are those which come into his hands, in payment of some debt or contract. When bills receivable come to hand, the particulars of each are entered in the proper columns of the bill-book; as are those of the bills payable, when advice is received of their being drawn upon the merchant, or when they are presented for his acceptance. The use of the bill-books will be plain from the manner in which the two following bills are entered in the specimens of those books.

Livres 2400, *a* 30*d*. Paris, 4th June, 1814.

One month after sight, pay to the order of Mr. Adam Young two thousand four hundred *livres*. Exchange at 30 pence per *Ecu*. for value received.

Mr. James Moore, London. | Accepted 18th June, 1814, James Moore. | Richard Davies.

This bill is received by the merchant from his correspondents Messrs. Lebrun and Co. at Paris.

£500..0..0 London, 8th June, 1814.

Forty days after date, pay to Mr. Edward Hollis, or order, five hundred pounds, for value received.

Mr. P. Q. London. | Accepted 15th June, 1814, P. Q. | Joseph Wilson.

This bill drawn on the merchant P. Q. by Joseph Wilson, is entered in bills payable, in the following way.

N. B. The several particulars of bills are so numerous as to extend over both pages of the book: but for conveniency they are here broken into two portions.

			Bills receivable.				
Journal page	No.	When received.	From whom received	By whom and where drawn		On whom and where drawn	
1	1	June 18	Lebrun and Co. Paris	Davies	Paris	Moore	London

June, 1814.

Date		To whom payable	Time	Due		Sum		
June	4	Adam Young	1 month's sight	July	21	£100	0	0

Bills payable.

Journal page	No.	By whom and where drawn		Date		To whom payable
4	3	Joseph Wilson	London	June	8	Edward Hollis.

June, 1814.

Time	Accepted		Due		Sum			To whom and when paid	
Forty days, Date	June	15	July	28	500	0	0	Clerk of Bank	Jul. 28.

The *Sales-book*, or *Factory-book* shows the net proceeds upon any cargo or quantity of goods, sold by consignment on commission. A proper *account sales* generally occupies two opposite pages; the 1st, or left hand page containing the various charges incurred in the business, such as freight, custom, expenses of landing and selling the goods, with the brokerage and factor's commission, both of which are charged on the gross or total amount of the sales. The 2nd, or right hand page contains the quantity, price, and amount of the goods sold, with the name of the buyer and the time of payment. The difference between this gross amount and the charges on the opposite side, is the clear or net proceeds; for which the factor gives his correspondent credit, and sends him a copy of the account sales. But in small consignments an account sales is commonly comprised in one page, beginning either with the charges or with the amount of the goods sold. Of this last kind the following is a specimen, being an account of the sale of a pack of $\frac{7}{8}$ wide brown linen, sent from Dublin to London.

SALES-BOOK.

Sales of linen, 1 pack brown, $\frac{7}{8}$ wide, for Juno, on account of Patrick Murray, of Dublin.

London, 15th June, 1814.

P. M.	Sold Robert Townson, payable at 8 months.	£	S.	D.
$\frac{N}{1}$				

THE INVOICE-BOOK.

An Invoice is a paper sent off with goods exported on commission; and hence it has its name from the French *envoy*, any thing sent. In extensive concerns, copies of all invoices, sent off, and received, are copied into a book: but this labour may be saved in ordinary cases by preserving the originals in drawers or pigeon-holes, or filed, or pasted upon the leaves of a blank book, made for the purpose.

Invoice of sugar shipped on board the True Briton, Henry Powill master, for Malta, by order of Richard Andrews, merchant there, for his account and risk, and to him consigned.

London, 10th June, 1814.

R. A.	No.	Cwt.	Qr.	lb		Cwt.	Qr.	lb	£	S.	D.
No. 1—4.	1 Gross	9	2	12	Tare	1	0	15			
	2	9	1	22		1	1	10			
	3	9	0	18		1	0	17			
	4	9	2	16		1	1	12			
	Gross	37	3	12		4	3	26			
	Tare	4	3	26							
	Neat	32	3	14	at 95s. per cwt.				156	3	1
	Charges										
	Debenture entry					£4	19	0			
	Cost of hogsheads					1	15	9			
	Cartage, wharfage, lighterage, and bills of lading					1	7	3			
									8	2	0
	Commission on £164..5..1, at 2½ per cent.								3	13	11
	Premium of insurance on £180, at 1½					2	14	0			
	Policy duty					0	5	0			
	Commission at ½ per cent.					0	18	0			
									3	17	0
									171	16	0
	Drawback allowed at the Custom house								37	10	3
								£	134	5	9

Of the same nature, and intended for similar purposes with the invoice, although in a humbler style and form, are the common *bills of parcels*, delivered by tradesmen and shop-keepers to their customers, together with the goods they have purchased. Of these the following are specimens, in which the values of the several articles are left blank, the total only being given, as an exercise for the student in calculation.

A Grocer's bill.

London, 23rd of May, 1814.

Sir William Jones, Bart.

Bought of Richard Smith, Oxford street.

		£	S.	D.
33¾℔ of Imperial Tea	at 22s. 11½			
17½℔ of Royal green Tea	15s. 9¼			
26¼℔ of Best Bohea Tea	10s. 5¾			
44½℔ of Coffee	5s. 3¼			
30¾℔ of Double refined Sugar	1s. 7¾			
7 Loaves of Sugar, weight 109¾℔	11½			
		£ 86	6	2¼

A Linendraper's bill.

London, 25th of May, 1814.

The Honourable Mrs. Hervey

Bought of Perkins and Co. Strand.

		£	S.	D.
5 Pieces of Irish Linen, 23¼ yards each,	at 3s. 7¼			
37½ Yards of Diaper	1s. 9¾			
55¾ Yards of Holland	6s. 4½			
27¼ Yards of Muslin	5s. 8¼			
16½ Yards of Cambric	14s. 6½			
33¾ Yards of Printed Cotton	3s. 8½			
		£ 67	14	1¼

Of Receipts, Promissory Notes, Bills and Bonds.

These different sorts of writings so frequently occur in the course, not of commercial and mercantile only, but even of common life, that a few specimens of each, with some remarks on their nature and use cannot fail to be useful to young readers of all descriptions.

A Receipt is a discharge to a debtor for money he owed to the grantor of the receipt, and is a bar or absolute stoppage of all law-suits, whether in courts of law or of equity. When a receipt is given *in full of all demands*, it discharges all debts existing between the parties, prior to its date. If a receipt be given, although no money or other value be really given for it, unless it be obtained by force or fraud, such a receipt is valid and good.

A servant may give a receipt, in his own name, for his master, if he be accustomed to receive or pay money for his master's use: and a wife may also give a receipt for her husband, in her own name. When a receipt is given *in full*, although a condition be annexed to it, specifying a debt formerly contracted, yet such a receipt must stand good as a receipt in full.

A *Promissory Note* is an engagement for a sum of money, to be paid on demand, or at a certain future time. When the sum is due on demand, it is due immediately, and no actual demand is requisite: but when the money is to be paid to a third person, or where a penalty is declared in the case of non-payment, then a demand must be made.

A *Bill* is a single bond, without any condition. If a person acknowledge himself indebted to another by bill in the sum of *fifty* pounds, for instance, and by the same bill bind himself and his heirs in the payment of the said sum, in a *hundred* pounds, without inserting the person's name to whom he is bound by the penalty, it must nevertheless be taken as a good bond against him, for that sum and penalty. If a person insert in a bill these words, *I do owe and promise to pay to A. B. the sum of fifty pounds, for the payment whereof I bind myself to C. D. &c.* (that is to some other person,) yet this is a good bill for A. B. by the words in the beginning: but the words expressing the obligation to C. D. are void.

Bills of Exchange. There is a material difference between a bill of exchange payable to a person *or bearer*, and one payable to a person *or order*. A bill payable *to a bearer* is not assignable, so as to enable the acceptor to bring his action, should the drawer refuse payment. If a bank-bill payable to A. B. or bearer, be lost and found by a stranger, payment will be made to the stranger, (unless previous notice be duly given) and the bank will stand indemnified: yet A. B. may bring an action of trover against the finder, but not against any other person to whom the finder may have paid it away, for a real and valuable consideration. [*Trover* from the French word *trouver* to find, means that species of action at law, by which one is entitled to demand his property, when found in the hands of another, and who refuses to deliver them upon demand.] On the other hand a bill of exchange payable to a person *or order* may always be assigned to some other person, and the holder may bring his action in his own name, if payment be refused. A servant or clerk, &c. cannot accept a bill for his master, unless there be good evidence that he has authority so to do, as when a master allows a servant to draw bills, &c. If one partner of a company draw a bill of exchange expressing it be *for self and company*, all the other partners are bound by it. If the holder of a bill make no demand when it becomes due, or within a reasonable time, and the party on whom it is drawn shall fail, the holder must abide by the loss occasioned by his own neglect. If a bill of exchange be lost, notice must be given by a notary public, before witnesses, that it is lost or mislaid, and requiring that payment of it be made to no person without

his knowledge. Inland bills may be protested, three days after they become due, on the refusal or neglect of payment; and this protest being notified within fourteen days afterwards, to the person from whom the bill was received, he must pay the bill with interest and the charges of protesting; but if the holder neglect to make the protest and give notice thereof, he is liable to the loss.

Bonds. A bond is an obligatory deed in writing, whereby one party binds himself to another, to pay a sum of money, or to perform any other *lawful* act, such as to make a release, to surrender an estate, to perform a covenant, an agreement, &c. &c.; and it contains a penalty for non-performance. A condition not to use a trade, not to till or sow the ground, or any thing of that sort, manifestly against the public good is of course void; as is also a stipulation to indemnify a person for any prosecution to which he may be liable, in consequence of the bond, which is not only void but illegal. When no time is specified for the payment of a bond, it is presently due, and payable on demand. In a bond where several persons are bound *severally*, the person to whom the bond is granted has his option to sue either all the bondmen together, or all of them apart, and have judgments against each: but he can have satisfaction once only. If he, from favour, or for any other cause, wish to relieve one of the bondmen, he cannot grant that bondman a release; for that would be to release the whole: all that he can do in such a case is to grant the person whom he favours, an engagement not to prosecute him personally. An heir is not bound by a bond made by his predecessor, unless he be expressly named: but administrators and executors are bound by such a bond. If a bond have no date, or a false date, or an impossible date, as the thirty-first day of February, yet if it be sealed and delivered it is good: and if the surname only of the drawer be subscribed, and a blank be left for his christian name, the bond is still sufficient. If a bond be interlined in a part that is not material, it will not be hurt: but interlineations in material parts render the bond void.

Letters of Attorney. This deed may be executed by any person, if of full age: a man may give a power of attorney to his wife, or a woman to her husband, in cases relative to matters that do not personally concern him: the nature and purpose of such a deed being to convey the full power and authority of the maker to the party who is to accomplish the act in contemplation. In these instruments the authority must be strictly pursued and adhered to: where the party acting does less than the authority mentions, the act is in most cases void; but where he doth more than his authority warrants, it may be good for so much as he had power to do, but for nothing beyond it. If a letter of attorney be made to three persons jointly, two cannot execute it; nor can one act, where two are jointly appointed. The death of the maker generally determines the authority.

It is to be observed that all these writings must be duly stamped, according to the rates settled by parliament, otherwise they are void, and of no avail.

Forms of Receipts, Promissory Notes, Bills of Exchange, Bonds, &c.

London, 1st June, 1814.

Received from Mr. Abraham Brown, twelve pounds, twelve shillings, for a quarter's rent, due on the 15th of last month.

£12..12 Charles Danby.

London, 1st June, 1814.

Received from Mr. Edward Fane, forty-nine pounds, seventeen shillings and six-pence, in part payment for tobacco, sold to him on the 11th of April last.

£49..17..6 George Hunter.

A Rent-collector's receipt.

Beechly Park,
4th June, 1814.

Received this day from Mr. Joseph Kendal in cash, twenty-eight pounds, fifteen shillings, which sum, with seven pounds, nine shillings and four-pence, allowed for land-tax paid by him, and three pounds, fifteen shillings and eight-pence for necessary repairs, making in all forty pounds, is in full for half a year's rent, due at Lady-day last. I say, received the above for the use of Richard Allworthy, Esquire, by virtue of his letter of attorney.

£40..0..0 Leonard Martin.

London, 2nd June, 1814.

Two months after date, I promise to pay to Mr. Nathaniel Osborne, or order, the sum of fifty pounds, for value received.

£50..0..0 Philip Quarme.

London, 3rd June, 1814.

We, or either of us two, do hereby promise to pay to Messrs. Roberts and Scott, Cornhill, or their order, on demand, the sum of thirty-seven pounds twelve shillings, for value received; as witness our hands,

£37..12..0 Samuel Truman.
Valentine Williams.

A Bill of Debt.

Know all men by these presents, that I Jacob Fanshaw of the city of London, merchant, do owe and am indebted unto Henry Burman of the city of Westminster, banker, in the sum of six hundred and fifty pounds, of lawful money of Great Britain; which said sum I do hereby promise to pay unto the said Henry Burman, his heirs, executors, administrators and assigns, on or before the second day of January next, ensuing the date hereof. Witness my hand and seal, this fourth day of June, 1814.

Signed, sealed, and delivered in the presence of us	George Harris. Thomas Leake.	Jacob Fanshaw (seal)

A Bond.

Know all men by these presents, that I James Richardson of the parish of St. George in the city of Westminster, hosier, am held and firmly bound to Robert Marlowe of the said parish, grocer, in the sum of two hundred pounds, of good and lawful money of Great Britain, to be paid to the said Robert Marlowe, or to his certain attorney or attornies, his heirs, executors, administrators or assigns, for which payment I do hereby bind myself, my heirs, executors, administrators or assigns, firmly by these presents. In witness whereof I have hereunto set my hand and seal, this fourth day of July, in the fifty-fifth year of the reign of our sovereign lord George the Third, &c. and in the year of Our Lord, 1814.

James Richardson (seal)

The condition of the above written obligation is such, that if the above-bound James Richardson, his heirs, executors, administrators or assigns, do, will, and truly pay, or cause to be paid, unto the said Robert Marlowe, his heirs, executors, administrators or assigns, the full sum of one hundred pounds, of lawful money of Great Britain, on or before the twenty-second day of December next, ensuing the date hereof, then this obligation to be void, otherwise to remain in full force and virtue.

CHAP. VII.

GEOMETRY.

GEOMETRY is that branch of science which treats of the nature and properties of *lines*, *surfaces*, and *solids*. The name is a combination of two Greek terms, signifying measurement of earth, or simply land-measuring. Geometry like arithmetic must, in its general principles, have been known and practised from the earliest periods of human society: its origin is of course unknown. Herodotus, the most antient Greek historian, who flourished above 400 years before the Christian æra, refers it to the reign of Sesostris, king of Egypt, who opened numerous canals throughout that country, and divided the land among the inhabitants according to certain proportions. By others geometry is said to have arisen from the yearly necessity in Egypt of making fresh surveys and allotments of the land, after the overflowings of the Nile had levelled or otherwise effaced the limits and boundaries between the possessions of the several cultivators. It is however to the Greeks themselves that modern nations are indebted for the great and fundamental principles on which all the improvements of later times have been founded. The writings of *Euclid* in particular are to this day considered as the fittest to be studied, by all who desire to acquire a rational knowledge of this most useful and most entertaining part of science. In the following pages however all that can be done will be to lay before the student such an idea of the nature and advantages of the study of geometry, as may induce him to prosecute his enquiries in a more extended and regular way, than can be attempted in the present work. The mason and the bricklayer who rear the walls of a house; the carpenter who constructs the roof; the joiner who frames the doors, windows and stairs; the cabinet-maker who furnishes the tables and desks; the gardener who lays out his walks, seed-beds, and flower-plots;—these and various other kinds of artisans make daily use and application of practical rules, drawn from geometrical principles: an acquaintance therefore with the simplest and

plainest of those principles, and with their application, cannot fail to enlarge the artisan's notions, to increase his means of usefulness in the world, and consequently to promote in the highest degree his own advantage and interest.

Geometry, like every other part of science and art, has various terms appropriated to its own particular use: of these the following are the principal; all derived from the Greek language. An *Axiom* is a proposition or assertion of which the truth is at first sight so evident, that no proof or demonstration can make it more manifest: such as that two things both equal to a third, must be equal to one another:—that the whole of any thing is greater than any part of it:—that the whole of any thing is equal to the sum of of all its component parts:—that two bodies which precisely coincide with each other, or which precisely fill the same space, are equal the one to the other, &c.

A *Theorem* is a proposition where some truth is to be proved or demonstrated, and means a thing to be *shown*.

A *Problem* is a proposition containing some question requiring a solution, and means a thing to be *done*.

A *Corollary* is some consequence drawn from what was previously demonstrated or performed.

An *Hypothesis* is a supposition, or something taken for granted, in either the statement and enunciation, or the demonstration of a proposition.

To render geometrical, and of course arithmetical operations, the more concise, certain marks or signs have been adopted, of which those most commonly used are the following, viz.

($=$) Two parallel and horizontal lines signify equality: thus $AB=CD$ means that the line or the quantity expressed by the letters AB is equal to the line or the quantity CD.

($+$) The St. George's cross (or two lines the one horizontal and the other perpendicular, crossing each other) signifies that the quantities between which the sign is placed are to be added together: its name is *plus*, a Latin word signifying *more:* thus $A+B=C$, shows the sum of the quantities A and B to be equal to the quantity C: $5+7=12$.

($-$) A single horizontal line between two quantities denotes that the least of the two is to be taken from the greatest: its name is *minus*, a Latin word signifying *less:* thus $C-B=A$, shows the difference between C and B to be equal in value or magnitude to A: $12-7=5$.

($\times$) The St. Andrew's cross (two lines crossing each other at right angels, but both equally inclined to the horizon) signifies that the quantities connected by it are to be multiplied together: thus $5\times7=35$: $a\times m=n$.

The product of two quantities multiplied together, is also expressed by writing their characters close together: thus $a\times m$ is expressed by am. A quantity raised to the 2nd power or squared, is thus expressed a^2; one raised to the 3rd power or cubed, is thus written a^3, and so on.

($\surd$) This sign means the root of any number or quantity: thus

$\sqrt{a^2}$ means the square, $\sqrt{a^3}$ the cube root of the quantity represented by a.

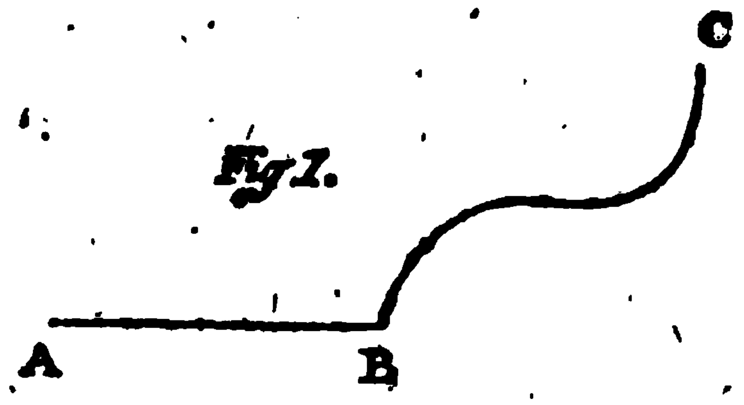
All bodies and the spaces which they occupy consist of three measures or dimensions, *length*, *breadth*, and *depth* or *thickness*. Although these dimensions are all absolutely necessary to the existence, and inseparable from the idea of a body of any sort, yet each of them, or any two of them, may be considered by us independently of the others. Thus for instance, when we say the Thames is deep at Woolwich, we are not considering the breadth of the river; when we say it would require so many square yards of carpet to cover a room, we think only of the length and breadth of the cloth, and not of its thickness; when we speak of the whiteness of the roof, we consider the colour alone, without in any way taking into the consideration the length or breadth of the roof, or even the thickness, however minute, of the paint or whitening by which the colour is produced.

1st. From the consideration of one dimension only or of extent between two given extremities, we have a notion of a *line*, in which its length alone is contemplated, although it be impossible to make or to conceive any line so fine and delicate, as to have no real perceptible breadth.

2nd. From the consideration of two dimensions, length and breadth, or height and breadth, we have the idea of a superficies or surface, although no substance can exist so thin as to have no real perceptible thickness.

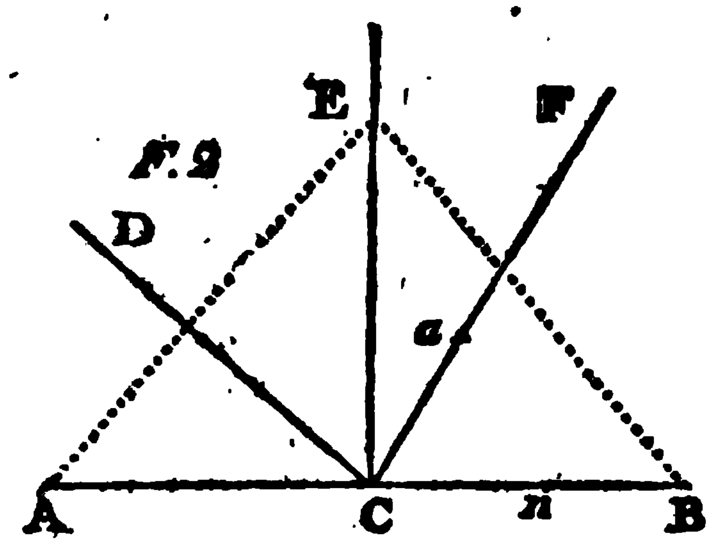
3rd. From the consideration of length, breadth, and thickness, or depth, we form a conception of solidity: thus by observing the length, breadth, and thickness of a squared log of mahogany, we form an idea, and can compute the number of the solid feet of timber it contains.

These three sorts of dimension or measure, all arise from what is called a mathematical point, such as (.) which is itself not susceptible of measurement: for although no point can be made, with the finest instrument and the most delicate hand, that shall not have some magnitude, and therefore have some length and breadth, however minute, yet these dimensions are not considered in reasoning concerning the point. When we apply the pen to the paper we make a point: if the pen be moved along the paper in any direction we form a line: supposing this line to be moved side-ways over the paper, as we move the edge of a ruler, the line would pass over and produce a surface; and this surface moved sideways would produce a solid figure. The extremities of lines are points; as are also the crossings or intersections of lines. The mark made by moving a point constantly in the same direction, from the beginning to the end of its motion, is termed a *straight*, or in geometrical language, a *right* line: on the other hand, if the mark made by the point deviate in even the smallest quantity from the original direction, it is no longer a *right* but a *curve* line. Hence it follows that only one *straight* line can be drawn between two given extreme points: but the variety of *curve* lines which may be drawn between the same points is infinite.



In the annexed figure A B is a straight or right line, B C a combination of curves, and the whole A B C is a mixed line.

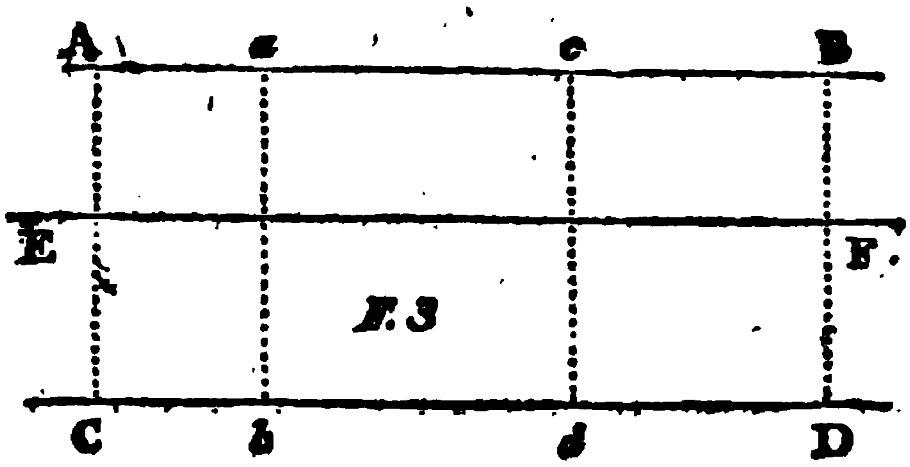
An angle, so named from *angulus* the Latin word for a corner, is the meeting of two lines, or it is the point in which two lines meet, of whatever kind they may be. Thus in the adjoining fig. 2, the two right lines F C and B C meet in the point C, and their meeting is called the angle at C, or more correctly the angle F C B or B C F: for in reading or naming an angle the letter standing at the point of meeting must be placed in the middle of the three. This is particularly necessary when more angles than one are formed at the same point, as in this figure where the three lines D C, E C, and F C all meet A B in the same point C: the angles made by these lines will therefore be read or named A C D, D C E, E C F, and F C B.

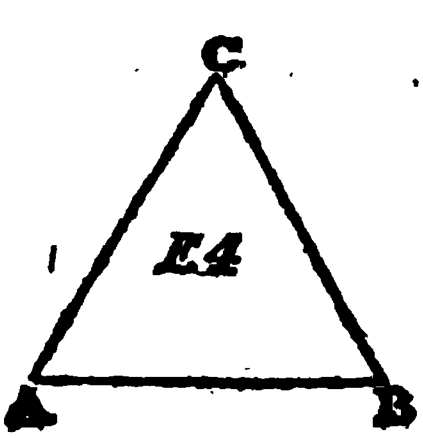


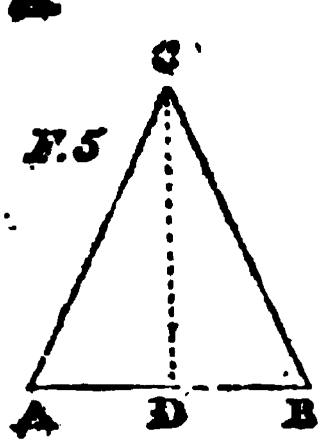
When one right line meets another in such a way that the openings on each side are equal, or when one line stands upon another, lying horizontally, in such a way that, if it were moveable, it would have no tendency to fall over on either side; in these cases the first line is said to be perpendicular to the second, and the equal angles are called *right* angles. Thus in fig. 2, upon the horizontal line A B stands E C, such that the openings on each side are equal; that is the distances E A and E B, measured equally remote from C, the point of meeting, are equal; in this case E C is perpendicular to A B, at the point C, and the two angles A C E and E C B being equal, are both right angles. But if the line F C meet A B in such a way that the angles are not equal, and consequently not right angles, the one as the angle F C A must be greater than a right angle, and the other F C B must be less: the greater is therefore said to be *obtuse* or blunt, and the less is *acute* or sharp. Angles like all other magnitudes may be augmented or diminished: thus the angle A C E is made up of the two angles A C D and D C E; and if to these we add the angle E C F, we have the whole angle A C F equal to the three angles A C D, D C E, and E C F. It is always to be remembered that in speaking of angles we mean nothing more than the mere opening formed by the meeting of two lines, without in the least taking into consideration the lengths of those lines: thus the

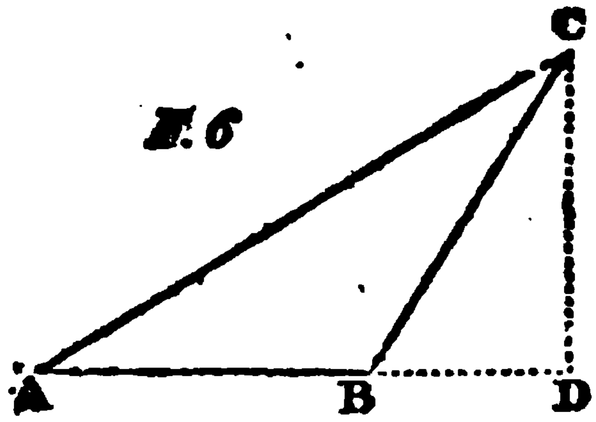
angle F C B is of the same magnitude, whether the lines forming it be in length only from C to *a* and *n*, or to F and B, or to points a thousand leagues distant from the angular point.

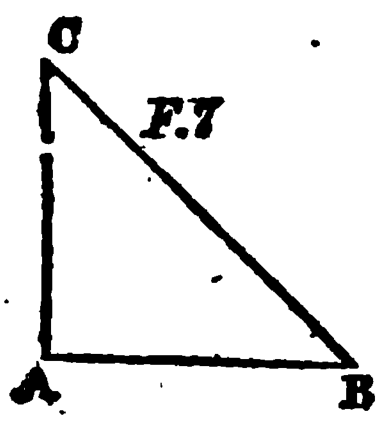
When two or more lines lie in the same plane or surface in such a way that, if produced to any imaginable length to right or left, still they would never meet, or have the smallest tendency to approach one another; such lines are said to be *parallel*, a Greek expression signifying one thing by the side of another. Thus in fig. 3, the lines A B and C D are situated that if they were produced or lengthened to any extent, from A and C, or from B and D, they would never approach one another: or in other words that the distance between them, measured at any points of their extent, as from A to C, from *a* to *b*, from *c* to *d*, from B to D, &c. would be constantly the same; in such circumstances the lines A B and C D would be parallel the one to the other. Lines parallel to any one line must be parallel to one another: for let A B and C D be drawn parallel to the middle line E F, then the distance E A being equal to the distance F B, and the distances E C and F D being also equal to one another; it must follow that the whole distance A C will be equal to the whole distance B D; and consequently that A B and B C, both made parallel to E F, are also parallel to each other. From what has been said it is evident that two right lines can never enclose a space: for if they meet at one extremity the others must be separate, and the longer the lines are, the greater will be the distance between their outer extremities. Suppose that the outer extremities of the lines A C and A B, which meet at A in fig. 4, were joined by the right line C B, we have now a figure consisting of three sides and three angles, and from the latter circumstance called by a Latin word, a *triangle*. When the three sides are all of the same length, the figure becomes an *equilateral*, that is an equal sided triangle as in this case. When only two sides are equal and the third either longer or shorter, as fig. 5, where A C and C B are equal, but A B is shorter, the triangle is said to be *isosceles* from Greek words expressing equal legged.





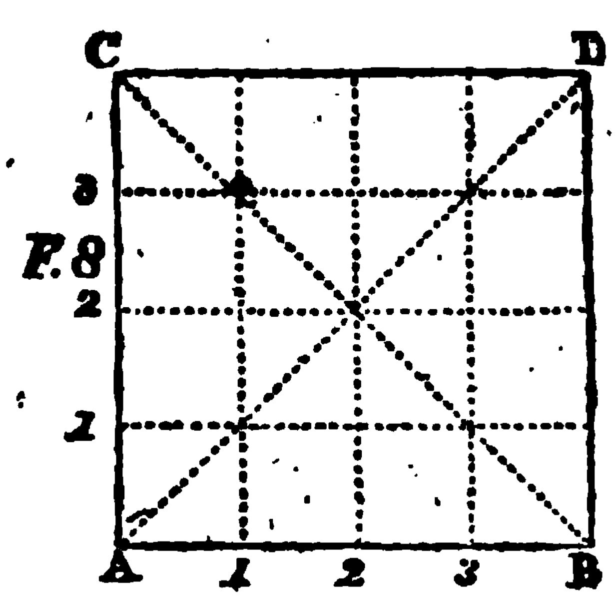


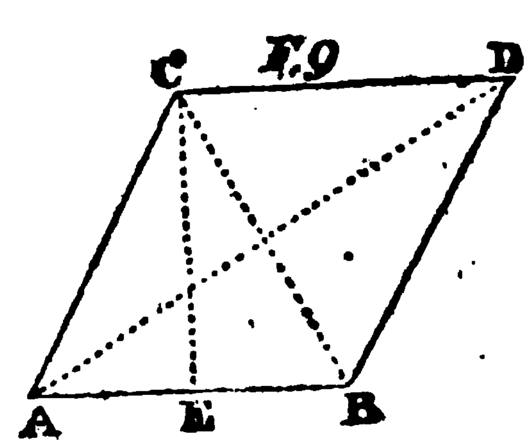




When the three sides are all of different lengths, as fig. 6, the triangle becomes *scalene*, a Latin term signifying leaning as a ladder against a wall. When one of the angles of a triangle is right, as the angle B A C in fig. 7, formed by A C standing perpendicular on A B, it is called a right-angled triangle; the lower side A B is called the *base*, the upright side A C is the *perpendicular*, because it seems to hang down from the point C, and the long side C B, opposite to the right angle at A, is the *hypothenuse*, (but properly called *hypotenuse*) because it is stretched out before the great right angle. If a line be let fall perpendicularly on the base of any triangle whatever, from the opposite angle, it will give the *altitude* of the triangle, whether it fall within the triangle, as C D the dotted line in fig. 5, or without the triangle upon the base A B produced to D, as in fig. 6, or coincide with the side of the triangle, as C A in fig. 7.

A figure inclosed by four sides is in general named from the Latin *quadrilateral*, signifying four-sided. When the four sides are all equal, and the four angles are all right and consequently equal, each side standing perpendicularly on the two adjoining to it, then the figure becomes a *square;* and it is from this property of the square that the word *square* is commonly, but inaccurately, employed to signify a right angle. Thus fig. 8 is a square, for the

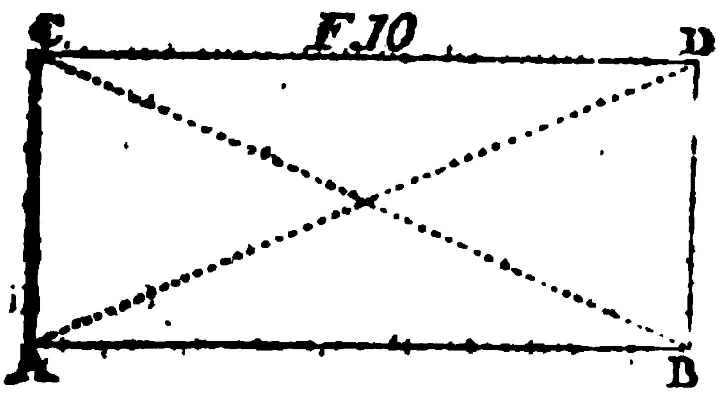


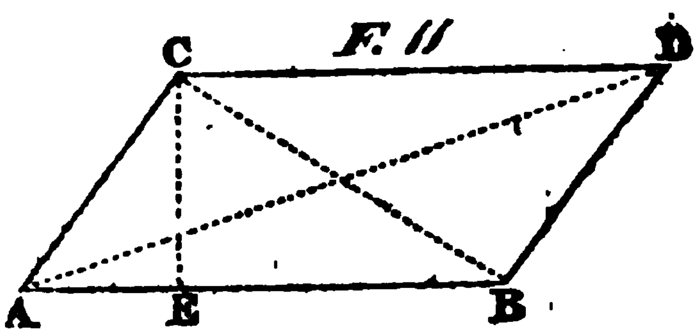


sides are all of the same length, and the angles are all right and equal, and it is said to be constructed on the line A B. If all the four sides be equal, but none of the angles right, the figure is called a *rhombus*, in which the opposite angles are always equal; such as fig. 9.

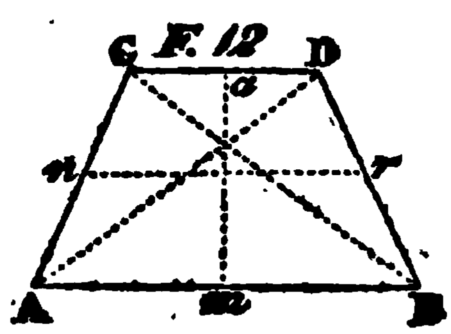
Four-sided figures having only the opposite pairs of sides equal

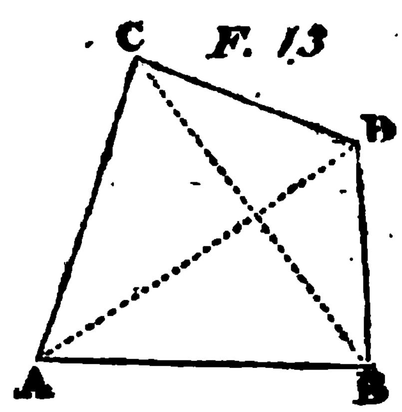
and parallel one to another, are in general called from this circumstance *parallelograms;* but when such a figure contains one right angle, (the remaining three being necessarily so likewise) it is called a *rectangle.* See fig. 10, where the opposite sides A B and C D are equal and parallel, as are also the opposite sides A C and B D: and the angle at A being made right, all the other angles





become right of course. If however the figure contain no right angle, but the opposite angles equal, and the opposite sides equal and parallel, the figure is still a parallelogram, but it is better described as a *rhomboid,* as fig. 11. When all the four sides are of unequal lengths, and of course the opposite angles are also



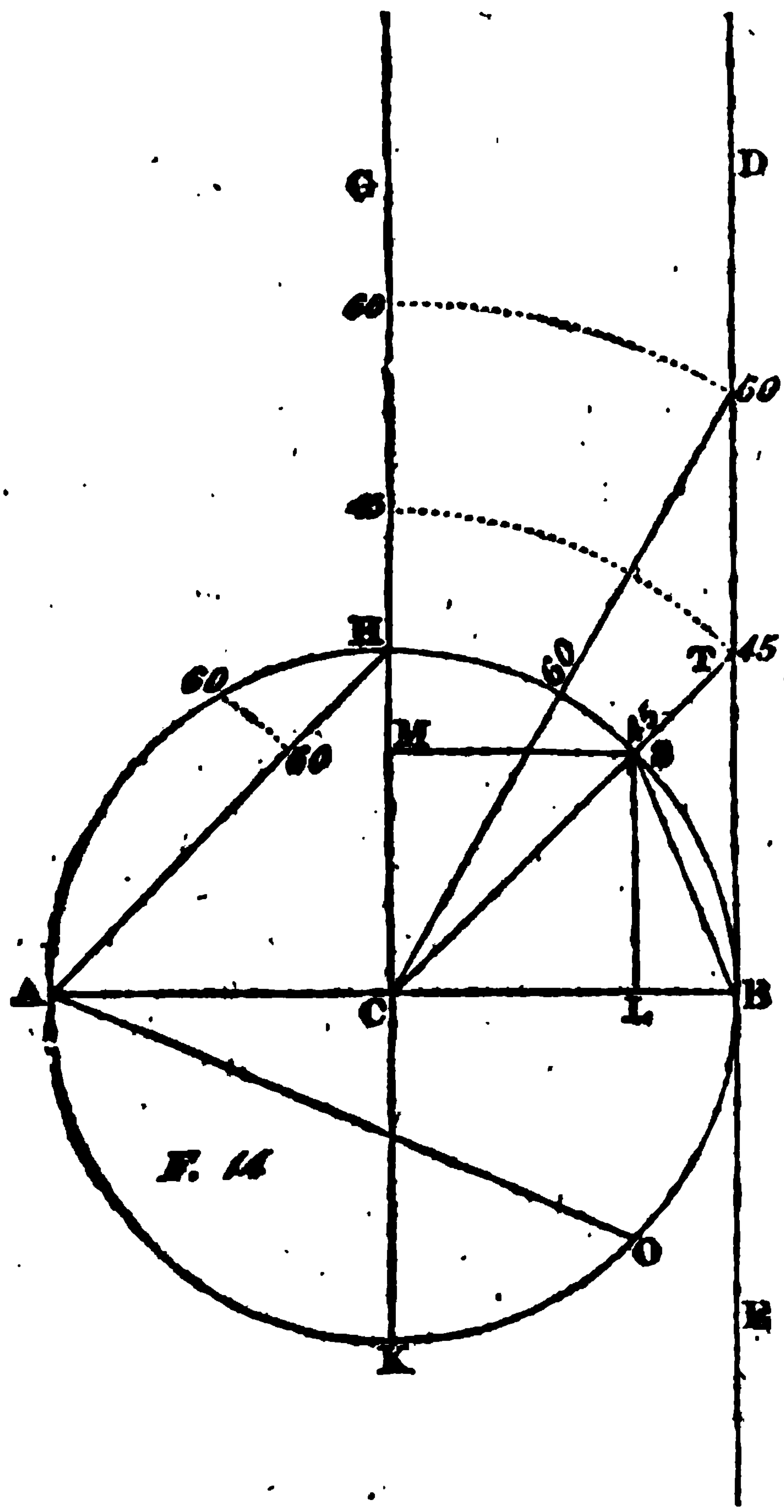


unequal, the figure is commonly called a *trapezium,* a Greek name properly signifying a table. (See fig. 12 and 13.) A line joining opposite angles in a figure, is called a *diagonal* from the Greek, because it cuts through the angles, as the dotted lines A D and C B in the several figures 8, 9, 10, 11, 12, and 13.

Figures composed of more than four sides, are distinguished by specific names formed from the Greek, and descriptive of the number of their sides, or more correctly speaking, of their angles, which are always of the same number with the sides; thus a figure of five sides or angles, is called a *pentagon,* one of six sides a *hexagon,* one of seven sides a *heptagon,* one of eight sides an *octagon,* one of nine sides an *enneagon,* or more commonly by a Latin term, a *nonagon,* one of ten sides a *decagon,* one of eleven sides a *hendecagon,* one of twelve sides a *dodecagon,* and so on: but in general figures with more than four sides are termed *polygons,* another Greek expression, signifying *many angles and sides.*

1.—Hitherto of figures inclosed by right or straight lines: we are next to give some account of those inclosed by curved lines, and first of the *circle.* Of the circle it is the distinguishing property and character, that every part of its *circumference* or *periphery,* (the first a Latin and the second a Greek word, signifying what is

carried or drawn round) is equally distant from a point within it called the *centre*. Thus in fig. 14 the curve A H B K is the circumference of a circle, of which C is the centre: every right line drawn from this centre to the circumference, is a *radius* of the circle, as C A, C H, C B, C K, a name derived from their resemblance to the *rays* proceeding from the sun, or the spokes of a carriage wheel. All lines passing from the one side of the circumference through the centre to the opposite side, are *diameters*, a Greek name referring to their reaching and measuring directly through the circle; such diameters are A C B, and H C K; and each is twice the length of the radius; for A B is made up of A C and C B, as H K is made up of H C and C K. All other straight lines drawn within a circle, and terminated at each end by the circumference, but not passing through the centre, are called *chords*, such as



F. 14

A H and A O. The longest line that can be drawn in a circle is a diameter passing through the centre; and all other lines or chords diminish in length in proportion as they pass farther and farther from the centre: thus the diameter A B is longer or greater than the chord A O, which is again greater than the chord A H, more remote from the centre. A diameter cuts the circumference and the area of the circle into two equal portions, called *semicircles*, a Latin expression for half-circles; thus the diameter A B divides the circle A H B O K into two equal parts, viz. A H B on the upper side, and B O K A on the lower; for both sides of the circle being described with the same radius or opening of the compasses, and the diameter A C B belonging to both, it is evident that if the semicircle A C B O K were lifted up and turned over upon the

diameter as a hinge, it would exactly cover the semicircle A C B H, the curve A K O B would precisely coincide with the curve A H B, and the two portions of the circle, separated by the diameter A C B, would be perfectly similar and equal. All other lines not passing through the centre, that is all chords, will consequently cut the circle into two parts, unlike and unequal the one to the other: thus the chord A O divides the circle into two unequal portions, the greater A H B O and the less A K O: in the same way the chord A H divides the circle into two portions much more unequal, the less A Z H, and the greater A K O B H. The several portions great or small, thus cut off by a chord are named *segments*, from the Latin term for a cutting or thing cut off. Any part of the circumference intercepted between two points is called an *arc* or *arch*: thus the portion of the circumference intecepted between the points A and H, the two extremities of the *chord* A H is called the *arc* A H, or A Z H, both terms borrowed from the resemblance of the curved part to the archer's *bow*, and of the straight line joining its extremities to the *chord*, *cord* or *string* of the bow.

It was before shown that the diameter as A B cuts the circumference into two equal parts: if through the centre C another diameter K H be drawn, at right angles, that is perpendicular to the former, it will likewise cut the circumference into two equal parts, K A H and K O B H. But things that are equal to one and the same thing must be equal to one another: the semicircle B H A must therefore be equal to the semicircle H A K. Again, the arc H A being a part of both of these semicircles it may be taken away, when the remainder of the one semicircle, namely B H must be equal to the remainder of the other, namely A K. But B H is also equal to H A; and in the same way it might be shown to be equal to B O K: we have therefore found that the whole circumference of the circle is cut into four equal parts, by the four extremities of two diameters, crossing each other perpendicularly in the centre. The figure included between these fourth-parts of the circumference, and a radius drawn to the centre from each extremity of the arc, will consquently be one fourth-part of the area of the circle; this fourth part is therefore, as well as the arc belonging to it, called a *quadrant*, a Latin word for a fourth part of any thing. But all other portions of the area of the circle comprehended between arcs, greater or less than a quadrant, and the radius drawn from each extremity of the arc to the centre, are called *sectors*, a cutting into the body of the circle: thus the figure contained within the arc B S, the radius S C, and the radius B C is a sector.

If at the extremity of a diameter as A.B, a line be drawn perpendicular or at right angles to it, that line if produced both ways will keep on the outside of the circle, touching the circumference at the point B, the extremity of the diameter: this line such as D B E will be a touching line, or rather, agreeably to the Latin term universally employed, a *tangent* to the circle at the point B. No line but one can be drawn a tangent to a circle

at any one point: for if it varied however so little from the first drawn, it would cease to be perpendicular to the diameter at that point, and would consequently on the one or the other side not only touch, but cut and fall within the circle. If from the centre of the circle a line as C S T be drawn, passing through the circumference at S, and meeting the tangent B D in T, that line is called the *secant* or cutting line of the arc S B, and the space B T of the tangent E B D is the *tangent* belonging to the same arc. If from the one extremity of an arc as at S a line be let fall perpendicularly on a radius drawn from the centre to the other extremity, that line as lying in the *bosom* of the arc is called a *sine*, from the Latin term for the bosom: thus S L becomes the sine of the arc B S, of which the straight line B S is the chord: in the same way the line S M falling perpendicularly on the radius C H, is the *sine* of the arc S H. But as the arc S H is the *complement* or what is wanting to the arc B S, to make up the whole quadrant B S H, the sine S M becomes the *sine-complement*, or shortly, the *co-sine* of the arc B S.

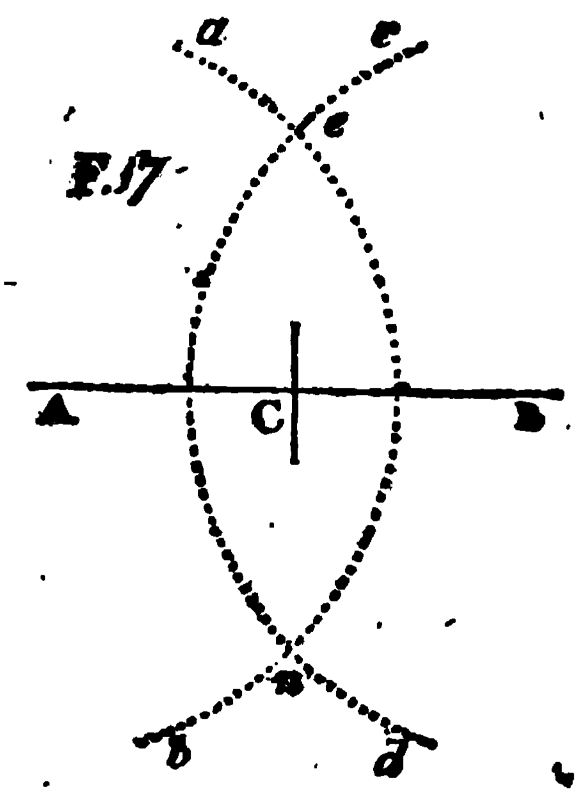
The circumference of the globe of the earth being divided into 360 equal parts called *degrees*, each degree into 60 equal parts called *minutes*, each minute into 60 equal parts called *seconds*, each second into 60 equal parts called *thirds*, and so on indefinitely, the same mode of measurement and subdivision has been applied to all circles, whatever be their magnitude: so that a degree of a circle however small, being the 360th part of its circumference, bears to its own radius precisely the same proportion with that which the degree of a circle however great bears to its radius. If the whole circumference therefore of the circle A H S B O K be divided into 360 degrees, a semicircle as A H S B, or B O K A must contain 180 degrees, and a quadrant or fourth part of the circle, as A H, H S B, B O K, or K A, must contain 90 degrees. If the point S be found equally distant between B and H, containing 90 degrees, then will the two arcs B S and S H each contain 45 degrees. Through this point S a line drawn from the centre C, and produced on till it meet the tangent B D in the point T, will cut off a portion B T, the tangent of the arc B S, that is of 45 degrees. If this line B T be measured by a pair of compasses it will be found just equal to C B, or to any other radius of the circle: the same radius will be found also equal to the chord of 60 degrees, set off on the great chord A H: so that the radius with which any circle is described is constantly equal to the tangent of 45 degrees, to the chord of 60 degrees, and to the sine of 90 degrees of that circle. To save room and time in geometrical operations, degrees, minutes, thirds, &c. are thus expressed: 85°, 27', 45'', 56''', &c.: that is to say, 85 degrees, 27 minutes, 45 seconds, 56 thirds, &c.

2.—Of the *oval* or *ellipse*. It was already said to be the characteristic of the circle that every point of the circumference was equally distant from the centre; consequently when the curve of any figure draws nearer to, or retires further from the centre, in one place than in another, that figure must cease to be a circle. All figures of this description formed by regular curves, varying

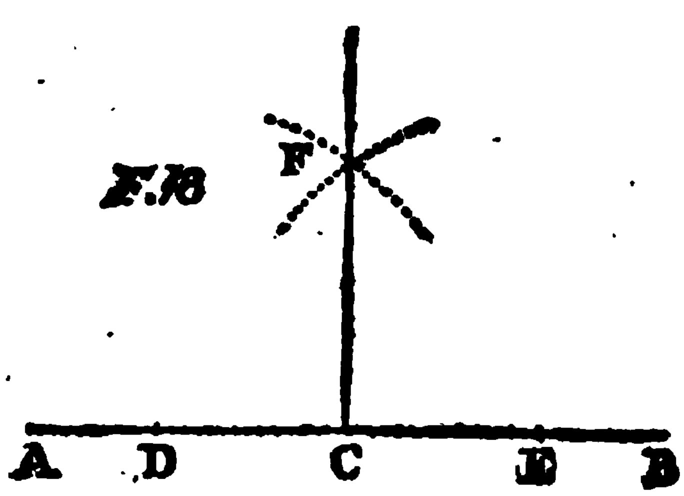
in shape in one fixed uniform manner, are called *ellipses*, or in common language *ovals*, from a general resemblance to an egg, called in Latin *ovum*. This last name is however very improper, because the one end of an egg is broader and rounder than the other, whereas a true oval line ought to have both ends precisely of the same shape and size. The proper term for such figures is *ellipse*, a Greek word signifying that something is deficient or wanting: because an ellipse drawn upon the same diameter and about the same centre with the circle will, in every part, excepting at the extremities of the diameter, fall within the circle: the ellipse must therefore be deficient in point of area or superficial contents, when compared with the circle of the same diameter. This deficiency will be evident from a look at Prob. xix. Fig. 18, where the ellipse A C B D falls considerably within the circle A X B Z, on the same diameter. Every right line passing through the centre of an ellipse, and terminated both ways by the circumference is, as in a circle, a diameter: thus A B passing through the centre, and C D crossing the other at right angles in C, are both diameters, the former being the longest and the latter the shortest that can be drawn in the ellipse. These two diameters however have peculiar names, to distinguish them from all other diameters that can be drawn; the longest A B being termed the *transverse* or *greater axis*, and the shortest C D the *conjugate* or *less axis*. Although E be the centre of the ellipse yet that point is not employed in drawing the circumference, but the two points F and G in the great axis A B. Each of these two points is called a *focus* of the ellipse; when they are chosen as near as possible on each side of the centre E, the ellipse will approach very nearly to a circle; and the farther they are removed on each side of the centre, but always at equal distances, the shorter will C D become in respect of A B; that is the narrower will the ellipse be, in proportion to its length, and the more it will recede from the shape of the circle.

Having thus briefly described the principal regular figures considered in geometry, it is now necessary to point out the method of constructing them, according to the rules of art, beginning with the operations required for their construction. These operations are called *problems*, because, as was before explained, something is not to be demonstrated, but performed; not to be shown, but done.

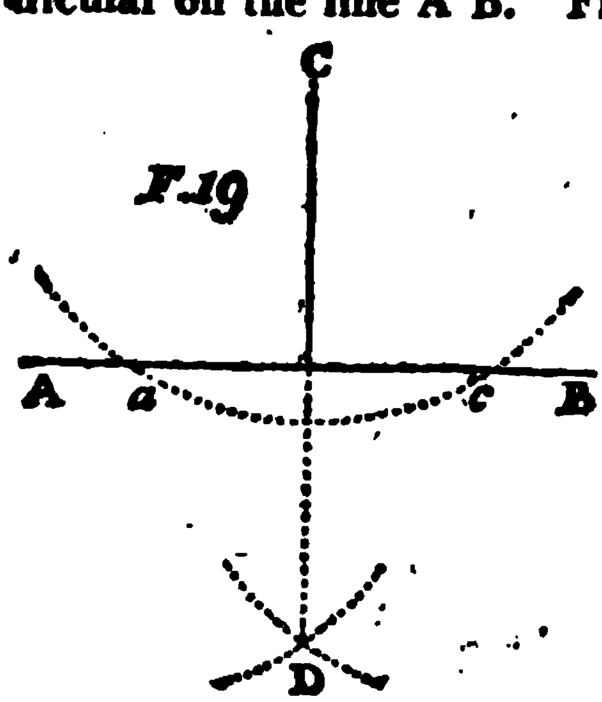
Problem I. Fig. 17. To bisect, that is to cut into two equal parts any given right line, as A B. Upon the extremity A, as a centre, and with a radius or opening of the compasses greater than half the line, describe the arc *a b*, and with the same opening from B, as a centre, describe the arc *c d*, intersecting the former in the points *e* and *n*: a line drawn joining these intersections *e n*, will cut the line A B in the point C, in such a way that A C will be precisely equal to C B: or in other words the line A B will be bisected, or cut into two equal parts, in the point C; which was the thing required to be done.



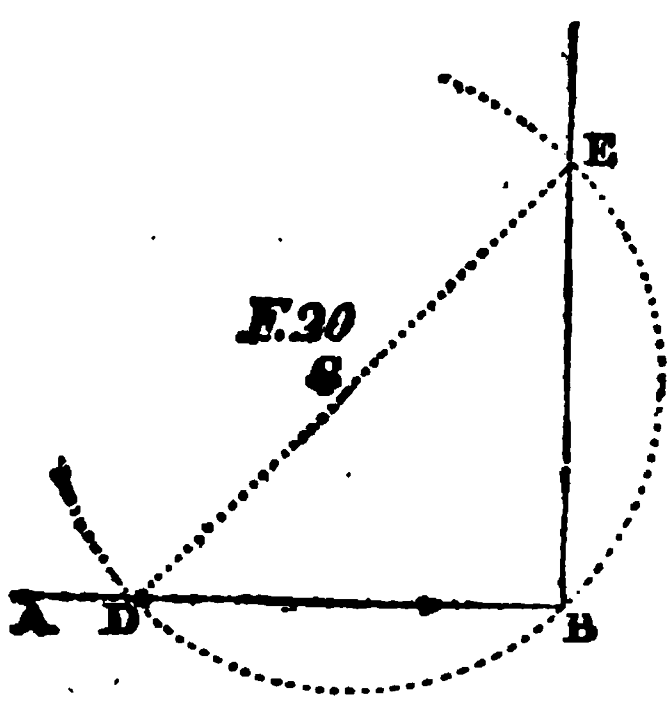
Prob. II. Fig. 18. From any given point C in the right line A B, to draw another right line which shall be perpendicular, or at right angles to A B at that point. With any convenient opening of the compasses, rather large than small, mark off the two points D and E, equally distant on each side of C: then from D and E, with a radius greater than D C or C E, make an intersection as at F, on that side on which the perpendicular is to be drawn, and a right line drawn through the intersection or crossing of the two arches at F, to the given point C, will be perpendicular to the given line A B at that point, as was required to be done.



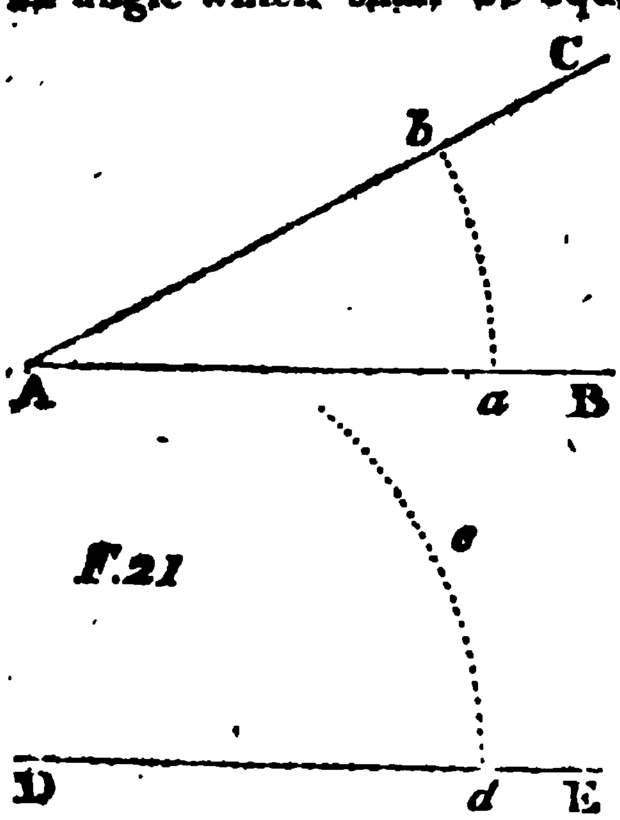
Prob. III. Fig. 19. From a given point C to let fall a perpendicular on the line A B. From C as a centre, with any opening of the compasses reaching beyond A B, describe an arch of a circle, cutting A B in the points *a* and *c*. From these points with any convenient opening make the intersection D, on the opposite side of A B, to the point C: a line drawn from C toward this intersection D, until it touch A B, will be perpendicular to it, and let fall from C, as was required.



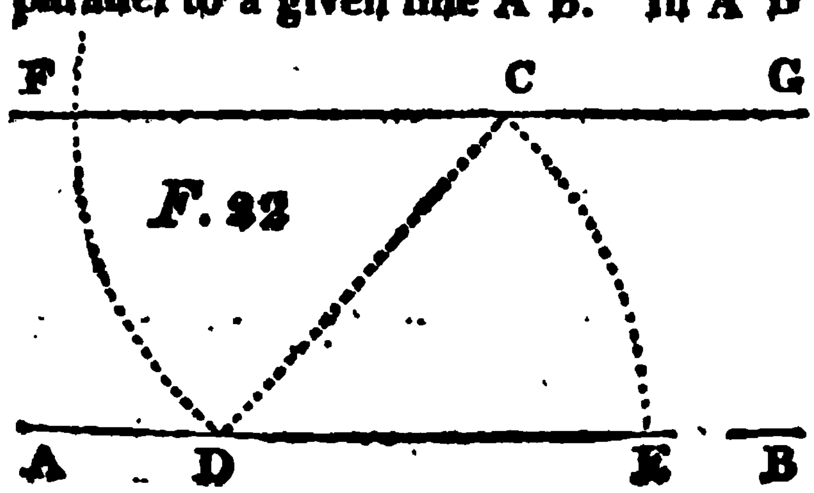
Prob. IV. Fig. 20. To erect a perpendicular on the extremity of a right line, as at B, the extremity of A B. Take any point as C, on that side of A B on which the perpendicular is to be erected, so situated that a perpendicular from it would fall considerably within the extremity B. From C with the radius C B draw the arch of a circle D B E, cutting A B in D. A ruler laid, or a line drawn from the intersection D, through the centre C, and cutting the arch at E, will give a point from which a line drawn to the extremity B, will be perpendicular to A B at that point: which is the thing required to be done. From this problem it is evident that when two lines are drawn from the extremities of the diameter of a circle and meeting at the circumference, these lines will always be perpendicular to one another; or in other words, that the angle in semicircle is a right angle.



Prob. V. Fig. 21. At a point as D, of a right line D E to make an angle which shall be equal to a given angle B A C. On A as a centre with any convenient opening, the larger always the better, describe the arc *a b*; with the same precise opening from D describe the arc *d e*: take in the compasses the space *a b* and set it up from *d* to *e*, and from D through *e* draw the line D F, which will, with the given line D E, form the angle F D E equal to the given angle C A B, as was required.

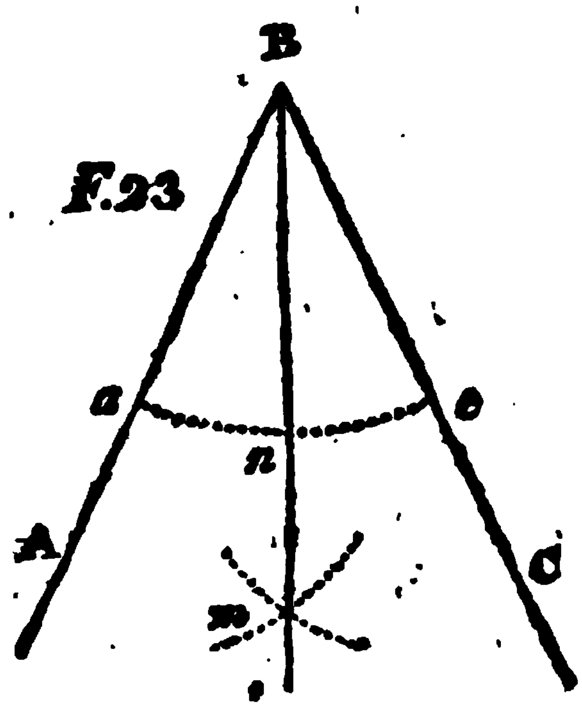


Prob. VI. Fig. 22. Through a given point C to draw a line parallel to a given line A B. In A B choose any point as D: with one foot of the compasses in D, and with the radius C D, draw the arch C E; with precisely the same radius, from C as a centre draw the arch D F, upon which set off D F equal to C E: through F and C draw the line F G,

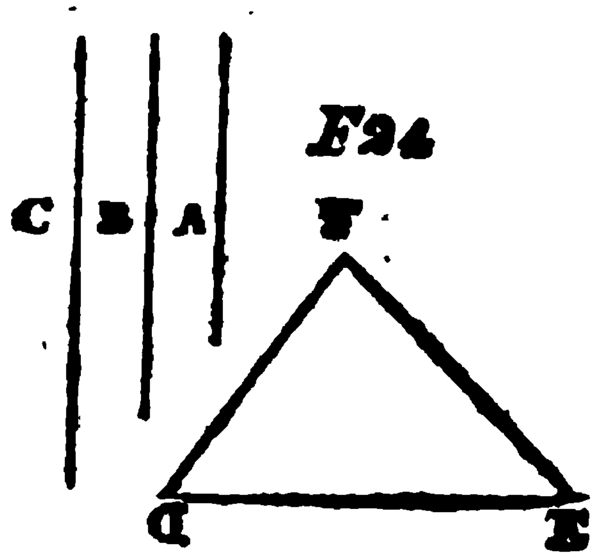


which will be parallel to A B, that is to say, every where equally distant from it, and it is drawn through the given point C, as proposed.

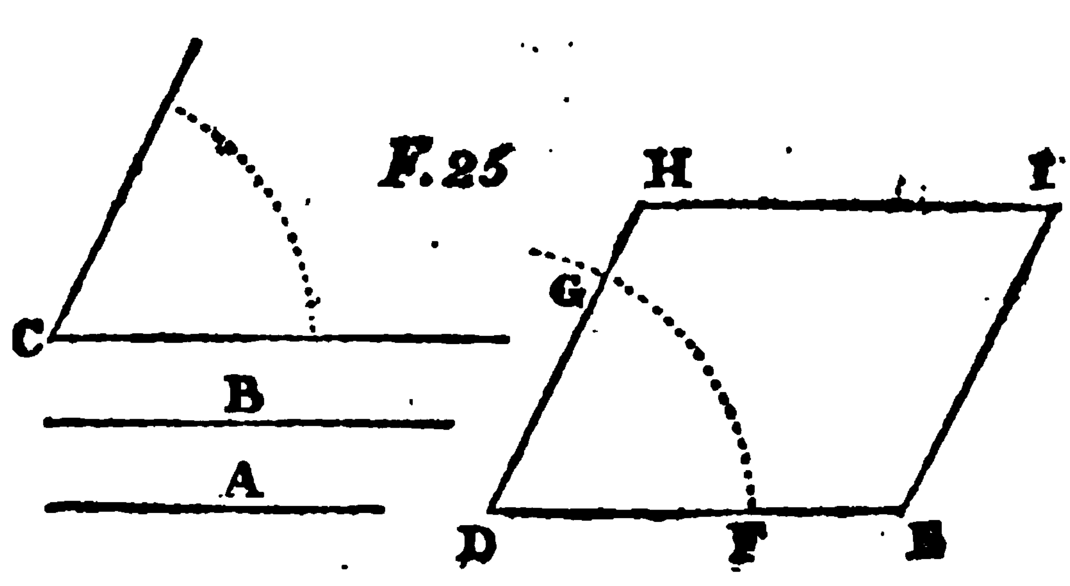
Prob. VII. Fig. 23. To bisect, or cut into two equal parts, a given angle A B C. On B, as a centre, describe the arc *a c*: from these points make an intersection at *m*: a line joining B and *m* will cut the angle A B C into two equal parts; consequently the angle A B *m* will be equal to the angle *m* B C. The same line B *m* also bisects the small arch *a c*, in *n*; so that *a n* is equal to *n c*.



Prob. VIII. Fig. 24. To construct a triangle of which the sides shall be respectively of given lengths, that is, equal to three given right lines A, B, and C. Draw the line D E, for the base of the triangle, and make it with the compasses equal to the longest line C: then with the length of A as a radius from D, draw an arch at F; with the length of B as a radius from E intersect that arch; join F D and F E, when the triangle D F E will be the figure required.

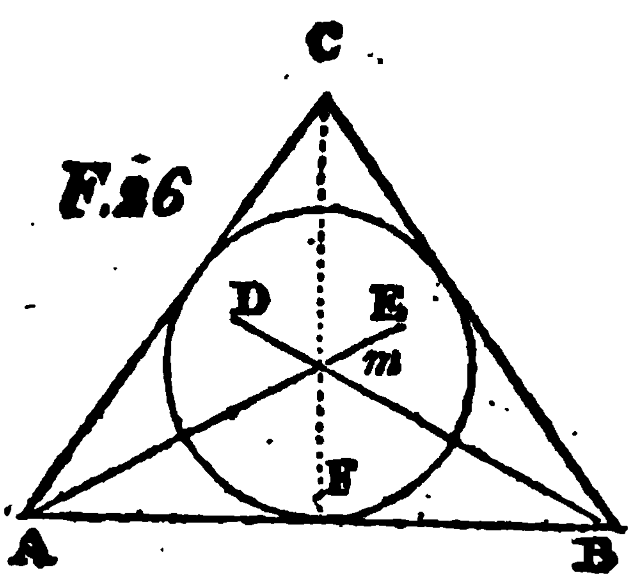


Prob. IX. Fig. 25. To construct a parallelogram of which the opposite sides shall be equal to two given lines, and containing an angle equal to a given angle. Let A and B by the lines to which

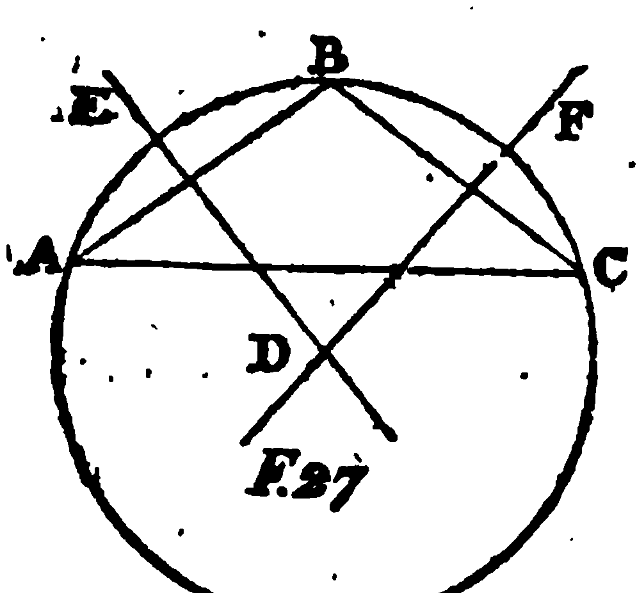


the sides of the parallelogram are to be made equal and the angle at C, that to which the angle made by these two sides is also to be equal. Draw D E, making it equal to the longest line B: upon that line (as was shown in Prob. v.) and at the point D, make the angle F D G or E D H equal to the given angle at C: make D H equal to the line A: then from E with the same opening of the compasses make an arch at I, and with the length of B, or of D E, set off from H, intersect that arch: join H I, and E I, when the parallelogram D H I E will be constructed according to the terms proposed.

Prob. X. Fig. 26. To inscribe or to draw a circle within and touching the three sides of a triangle as A C B. By the 7th Prob. bisect any two of the angles as A B C by the line B D, and B A C by the line A E cutting the former in the point *m*; this point will be a centre, from which perpendiculars let fall on the sides will be radii of the required circle, which will just touch the three sides of the triangle, and is consequently the greatest circle that can be inscribed within it. Had the remaining angle A C B been bisected by the line C F, it would here equally meet the two former bisecting lines in the same point *m*.

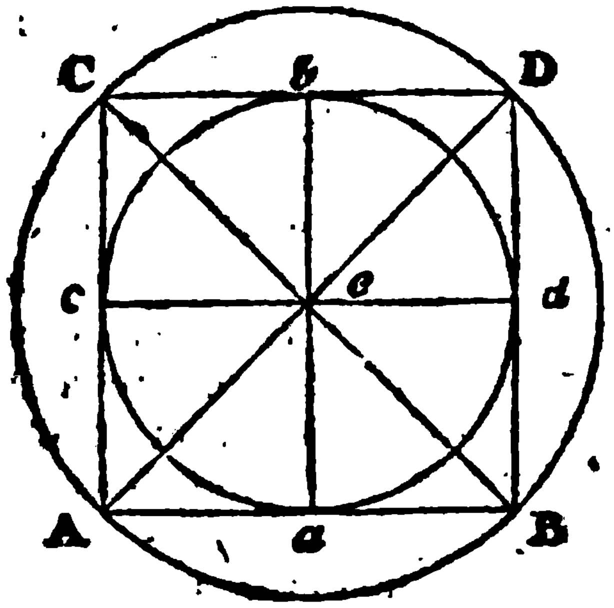


Prob. XI. Fig. 27. To find the centre of a given circle, or of the arch of a circle. Let A B C G be a circle, or A B C be an arch of a circle, of which it is required to find the centre. In the arch take any three points as A B and C, draw the lines A B and B C. By Prob. I. Fig. 17. bisect A B by the line E D, and B C by the line F D, meeting the former line in D, which will be the centre of the arch A B C, and of the whole circle A B C G. In the same manner a circle may be drawn that shall pass through three given points as A B C, provided they do not lie in one right line; and consequently through the three angular points of a triangle, when the circle is said to be circumscribed about the triangle, as in the same figure where, by joining the points A and C, the triangle A C B is formed.



Prob. XII. *Fig.* 28. To construct a square of any given dimensions. Let A B be a line upon which it is required to construct a square. Upon A, as directed in Prob. iv. Fig. 20. erect a perpendicular A C, making A C equal to A B: then at B with the same distance make an arch at D, and from C with the same opening make an intersection: right lines drawn from this point D to B and C will complete the required square A C D B.

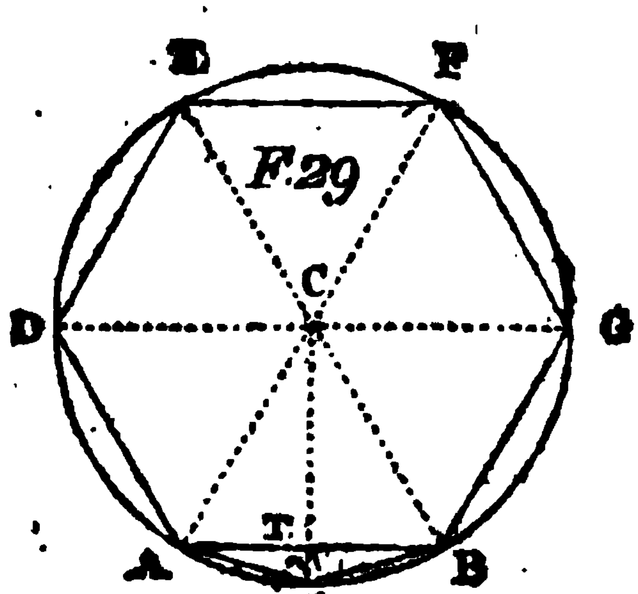
F.28



Prob. XIII. (See preceding figure.) To describe a circle within a square that shall just touch its sides, and consequently be the greatest possible. Divide each of the four sides into two equal parts in the points *a* and *b*, *c* and *d*: join them by the lines *a b* and *c d*, crossing each other in the point *e*: this will be the centre of a circle which, described with a radius equal to any one of the distances *e a*, *e c*, &c. (all equal to the half of the side of the square) will touch the sides of the square in the points *a c b* and *d*, and consequently will be the greatest circle that can be inscribed in the given square.

Prob. XIV. (See Fig. 28.) To circumscribe a circle about a given square as A C D B. Draw the two diagonals A D and C B, intersecting and bisecting each other in *e*: on this point as a centre with the distance *e* A, *e* C, &c. describe a circle which will pass through the four angular points of the square A C D B. From the construction of this and the preceding problem, it is evident that the diameter of the inscribed circle is always equal to the side of the given square, and that of the circumscribed circle to the diagonal of the given square.

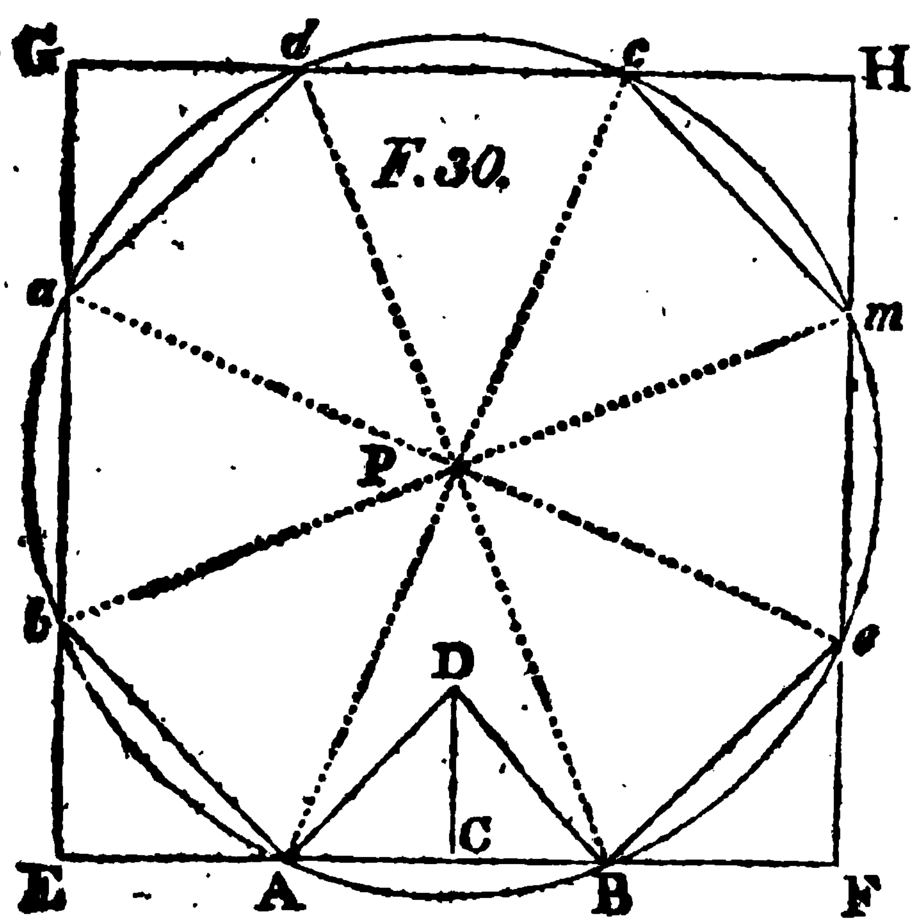
Prob. XV. *Fig.* 29. Upon a given line A B to construct a regular hexagon, that is a figure of six equal sides and equal angles. From A with the radius A B make an arch, and from B with the same distance intersect that arch at C: then from C as a centre with the same distance describe a circle passing through the points A and B: next, still with the same distance A B in the compasses, set off from A the distance A D, and from B the distance B G, upon the circumference of the circle: again from D set off D E, and from G set off G F. Lines drawn joining A D, D E, E F, F G, and G B, will, with the given line A B, construct a regular six-sided figure or hexagon, upon A B, as required.



If lines from the centre C be drawn to each of the angular points,

the hexagon will be divided into six equilateral triangles, as shown by dotted lines in the figure.

Prob. XVI. Fig. 30. On a given right line A B to construct a regular octagon or figure of eight equal sides and angles. Bisecting A B in C erect the perpendicular C D equal to the half of A B, and join A and D: then having continued the given line to a proper distance in both ways, from A set off A E equal to A D, and from B set off B F of the same length: by these steps is obtained the whole line E F, the side of a square which will just include the required octagon. Let this square be constructed as shown in Prob. xii. namely, E G H F. Then placing one foot of the compasses in E, and with the distance E B upon the base, make a mark at *a* upon the side E G: next from G, with the same distance make marks on G E at *b*, and on G H at *c*: again, from H make the marks at *d* and *e*; and lastly, from F make a mark at *m*. Lines drawn from A to *b*, from *a* to *d*, from *c* to *m*, and from *e* to B, will with the intermediate portions of the sides of the square, produce the octagon A *b a d c m e* B, constructed on the line A B, which was the thing to be done.



Prob. XVII. (same figure.) To convert a square into a regular octagon. Let E G H F be a given square which it is required to convert into a regular figure of eight equal sides and angles. Draw so much as may be requisite of the diagonals from E to H, and from G to F, intersecting each other in the point P: then with the distance E P, and on E as a centre, turning the compasses about make a mark on E G at *a*, and on E F at B; from G make similar marks with the same distance at *b* and *c*; from H make the marks at *d* and *m*; and from F the marks at *m* and A. Lines drawn as formerly from A to *b*, from *a* to *d*, from *c* to *m*, and from *e* to B, will with the intervening parts of the sides of the given square, form the required octagon A *b a d c m e* B, out of the square E G H F.

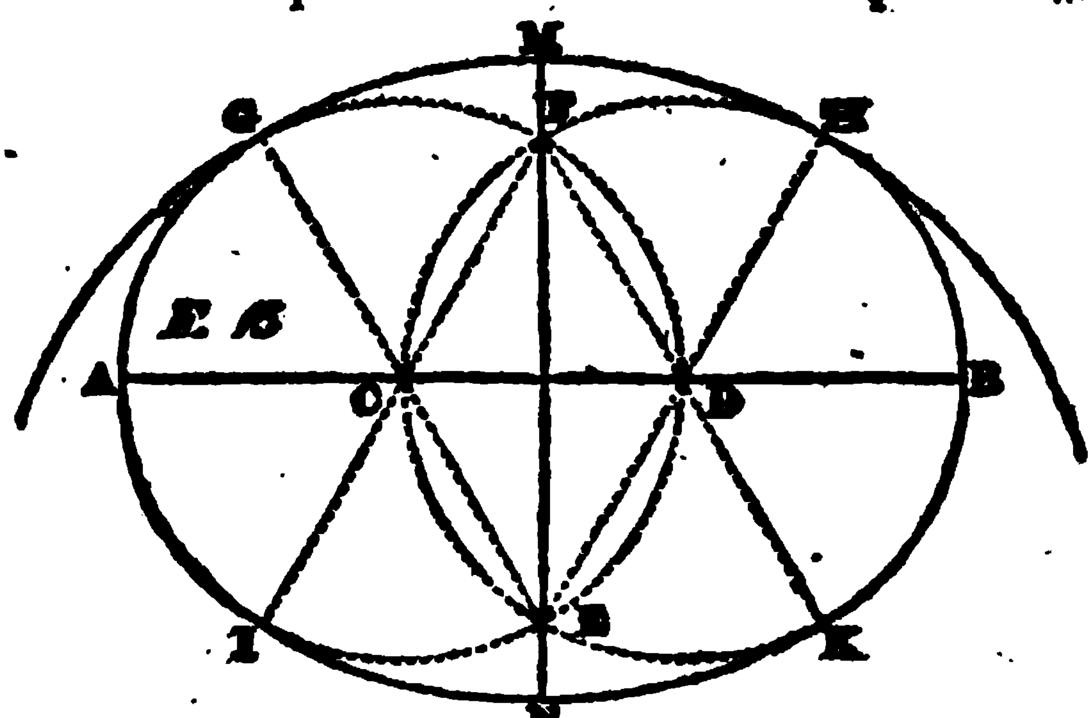
Prob. XVIII. To construct a dodecagon, or figure of twelve equal sides and angles, within a given circle. First divide the circumference of the circle into six equal parts, as in Prob. xv. divide A B the side of the hexagon into two equal parts in *x*, through which the line C *a* drawn from the centre will cut the circumference of the circle in *a* which, by Prob. vii. will divide the arch A B into two equal parts likewise. But A B as the arc of a hexagon, is the sixth part of the circumference; and A *a* being the half of

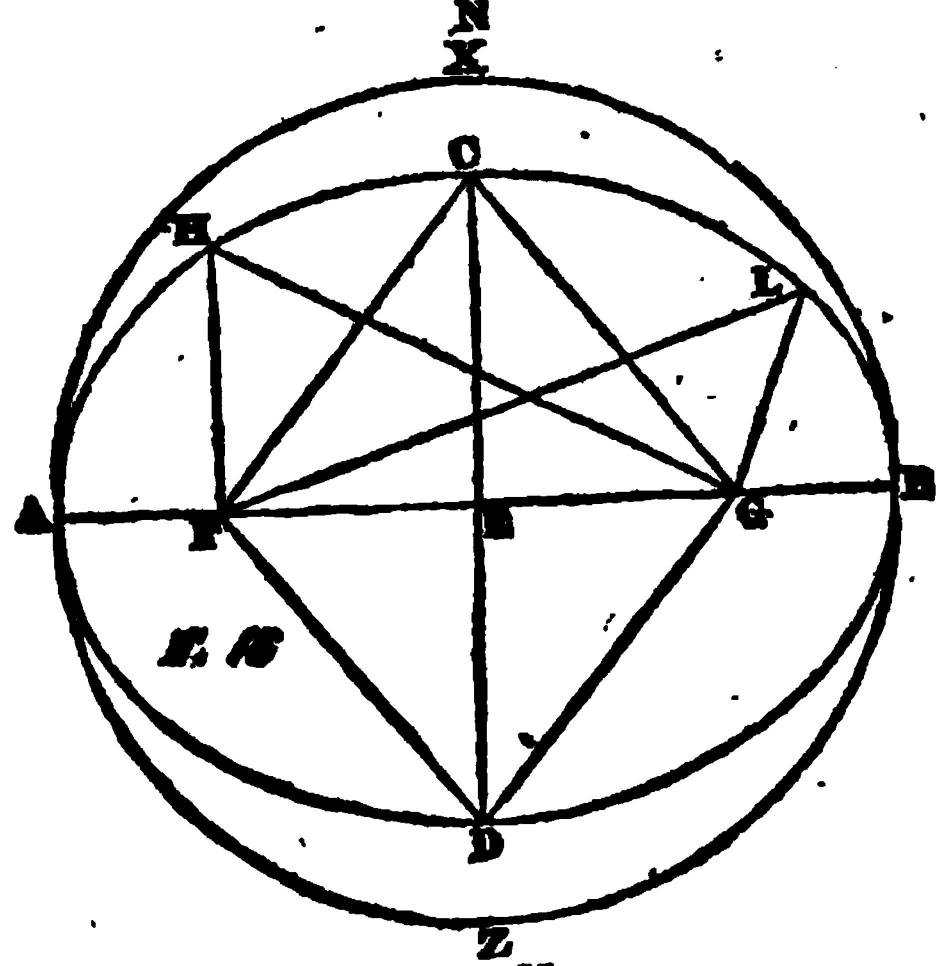
A B must consequently be the twelfth part of the circumference: if therefore the line A *a* be drawn, it will be the side of a dodecagon; and if each of the arches opposite to the sides of the hexagon be divided into two equal parts, the chords A *a*, *a* B, &c. will form a regular dodecagon.

Again, to construct a regular figure of sixteen sides, we have only first to draw an octagon, as in Prob. 16; then on P as a centre, with a radius equal to the distance from P to any of the angles of the octagon, as P A, describing a circle as in the figure, we divide the arch A B into two equal parts in *s*; and drawing the lines A *s* and *s* B, we obtain two sides of a figure, corresponding to one side of the octagon: then twice 8 being 16, if each side of the octagon be cut into two equal parts, we obtain the figure of sixteen equal sides and angles required.

Prob. XIX. Fig. 15, and 16. To draw an ellipse. The nature of the ellipse, improperly called an oval, has been already described: it still remains to show the methods of representing it upon paper, a table, a floor, or other plain surface.

1st. Let it be required to construct an ellipse of which the





greatest length or transverse axis is A B, and the greatest breadth or conjugate axis is M N, in fig. 15. Divide A B into three equal parts by the points C and D: upon C as a centre, with the radius C A describe a circle, passing through A and D; then upon D, with the same radius describe another circle passing through C and B, and crossing the first circle in the points E and F. From the intersection E, through C draw E G to the circumference, and through D draw E H: again from the intersection F, through C draw F I, and through D draw F K. Then on E as a centre, with E G or E H, for they are equal, as radius describe the arch G M H; and on F as a centre, with F I, or F K as radius, draw the opposite arch I N K; when the external curve A G M H B K N I will be the ellipse required.

2nd. The foregoing method is commonly recommended; but it is extremely erroneous; for it can produce only a figure that may deceive the eye, by a general resemblance of a true oval, besides that the proportions between its length and breadth must be, in all cases the same, whereas the lengths and breadths of ellipses may admit of unlimited variety of proportions. That the ellipse drawn by that method is not one continued curve, but a combination of different curves, is evident from figure 15, where the arch described from E, instead of coinciding or uniting with the arches G A I and H B K, would, if produced either way, depart widely on the outside of the ellipse: in the same manner the opposite arch I N K would pass to a great distance on the outside of the same circular arches. Hence it follows that no true ellipse or oval can be drawn by compasses; the ellipse being drawn by a radius from each focus, the length of which is continually changing, whereas compasses act always from one centre, and with a radius constantly of the same length. Other methods have been adopted, of which the best is to find by the properties of the figure a succession of points in the circumference, and to fill up the interstices between these points by the hand: but after all this is but an approach to the truth which, where no great accuracy is required, may be safely employed. An ellipse or true oval can therefore be correctly drawn by mechanical processes alone, founded on this simple but characteristic property of the figure, that right lines drawn from all points whatever of the circumference, to the two *foci*, will, when taken together, be constantly equal the one to the other. Thus in fig. 16, let A B be the long axis of an ellipse in which F and G are the *foci*, from which the figure is described. Let H, C, L, D, be points in the circumference from which lines are drawn to each focus: then the sum of F H and H G, of F L and L G, of G D and D F, will be always equal the one sum to the other. To proceed in the construction of the required ellipse, draw A B and C D crossing it at right angles in E: E A and E B each one half of the long axis, and E C and E D each one half of the short axis; then will A B and C D show the dimensions of the ellipse to be drawn. Taking one half of the axis A B in the compasses, place one foot in C or D, and with the other cut A B in the points F and G, which will be the *foci* of the ellipse. Take a

piece of strong thread or cord, that will not easily stretch upon slight pressure, which including a small loop at each end, must be precisely equal to A B: placing pins or nails in the points F and G, over them respectively lay the loops at the ends of the thread: with another pin or pencil in the double of the thread, stretched so as to be at its full extent and no more, as at C, carry the pin or pencil round to A and there applying it to the paper, or floor, carrying it round to the right in the double of the thread, kept always on the same stretch, it will describe the regular curve A H C L B. Then turning the pin and thread to the other side of A B, a similar curve will be drawn A D B, which will complete the ellipse upon the given lengths of A B and C D as was required. Instead of the pins and thread an instrument called the *trammels* has been adopted, where a ruler is, by means of grooves cut in two other rules fixed at right angles, made to describe an ellipse of any proportions, with the greatest accuracy; because the rulers are not liable to alter their lengths, an accident which cannot be entirely avoided, by even the most delicate hand, in using a thread or cord of any sort.

3rd. Of *regular polygons*, or figures of a great number of sides. It was already said that all circles are supposed to be divided into 360 degrees, consequently all the angles that can be formed at any one point must be equal to that quantity. If then we divide 360 by the number of sides in any polygon the quotient will give the number of degrees in each angle formed at the centre of the figure by lines drawn to the extremities of each side. Thus Fig. 29 is a regular hexagon, or polygon of six sides. If from the centre C, lines be drawn to the extremities of the sides, as C A, C D, C E, C F, C G, and C B, six angles will be formed round C, the sum of which must be equal to the circumference of the whole circle inclosing the polygon. 360 divided by 6 will give 60 deg. for each angle at the centre: consequently in the triangle A C B for example, we have the angle at C 60 deg. It is a constant property of every right-lined triangle, of whatever shape it may be drawn, that the sum of its three triangles is always equal to the sum of two right angles, or twice 90 deg. or 180 deg. This being the case, if from 180° we subtract 60°, the remainder 120° must be the sum of the two angles at the base C A B and C B A. But the sides C A and C B being equal, each being a radius of the same circle, it follows that the angles oposite to these equal sides must also be equal, consequently each of those angles will contain 60°. Further, the angle C A D is equal to the angle C A B, as is C B G to C B A: the great angles D A B and A B G must therefore be double C A B and C B A: consequently the angle formed by the sides of any polygon is always equal to the difference between the angle at the centre and 180 deg. Hence we have an invariable rule for constructing a regular polygon upon any given side. Let it be required for example, to construct upon A B, Fig. 30, a regular octagon. By dividing 360° by 8 we have 45° for the angle at the centre A P B, which subtracted from 180° will leave 135°, the half of which 67° 30′ is the angle P A B or P B A.

Then upon the given side A B construct with a scale the two angles B A P, A B P, each of 67° 30', and draw the forming lines meeting at P: this will be the centre of a circle which passing through A and B will comprehend the required polygon. On this circle apply the length of A B, which will mark off the extremities of the polygon to be constructed.

The annexed table shows the number of sides of various regular polygons, from a triangle to one of 20 sides, the angle formed at the centre of each figure, by lines to each angle, the angle of the polygon formed by the meeting of two adjacent sides, and the angle at the base of each triangle, formed by a side of the polygon and lines drawn to the centre.

Sides	Cent. ang.	Ang. of Polyg.	Ang. of Tr.
3	120°	60°	30°
4	90	90	45
5	72	108	54
6	60	120	60
7	$51\frac{3}{7}$	$128\frac{4}{7}$	$64\frac{2}{7}$
8	45	135	$67\frac{1}{2}$
9	40	140	70
10	36	144	72
11	$32\frac{8}{11}$	$147\frac{3}{11}$	$73\frac{7}{11}$
12	30	150	75
15	24	156	78
16	$22\frac{1}{2}$	$157\frac{1}{2}$	$78\frac{3}{4}$
20	18	162	81

CHAP. VIII.

PRACTICAL GEOMETRY, &c.

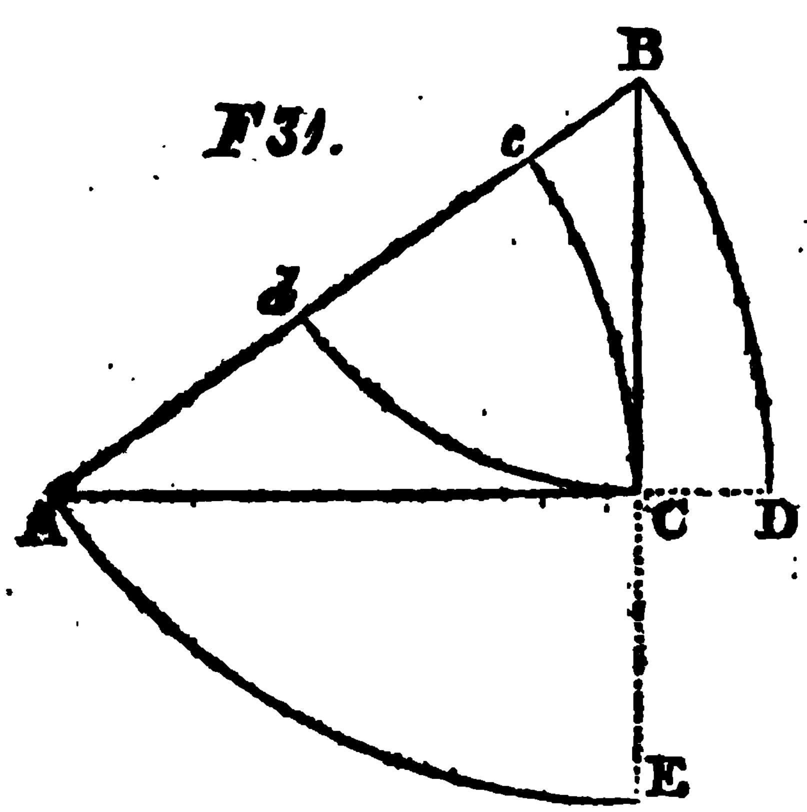
ALL superficial figures either are, or may be reduced into triangles: the circle itself, the ellipse, curves of every sort can be measured geometrically only as composed of straight lines forming triangles. (See *Circle* in Mensuration.) Hence it follows, that by whatever means we can measure a triangle, by the same means we may measure every other plane figure. This branch of geometry is therefore styled *trigonometry*, from two Greek words, signifying the measurement of triangles.

Trigonometry is divided into two branches, *plane* and *spherical*. Plane trigonometry relates to triangles formed by straight lines upon an even surface, as upon a sheet of paper, on a drawing board, or the like. The smoothest, even, level plain on the surface of the earth is not indeed a mathematical plane surface, because it is a portion of the spherical surface of our globe: but a line of even 6 or 8 miles in length, measured on this spherical surface, differs so little from one measured on a true level, that the former may be employed in all ordinary cases, in the room of the latter. Spherical trigonometry relates to triangles of which the sides are not straight lines but curves, and particularly arcs of the circles supposed to surround the earth, or to mark out the relative positions of the heavenly bodies. This last branch of trigonometry is indispensibly necessary for duly understanding the grounds and reasons on which are constructed the science and practice of astronomy, geography, and navigation: but to give even a general notion of spherics would demand much more preparatory instruction, than can be introduced in a work of this sort. The student will therefore consent, when he peruses those articles, to do as he does, and as he must do, in the concerns of common life: he must admit to be true, and receive as certainly established, a multitude of facts of which neither is the nature fully explained, nor even the existence demonstrated.

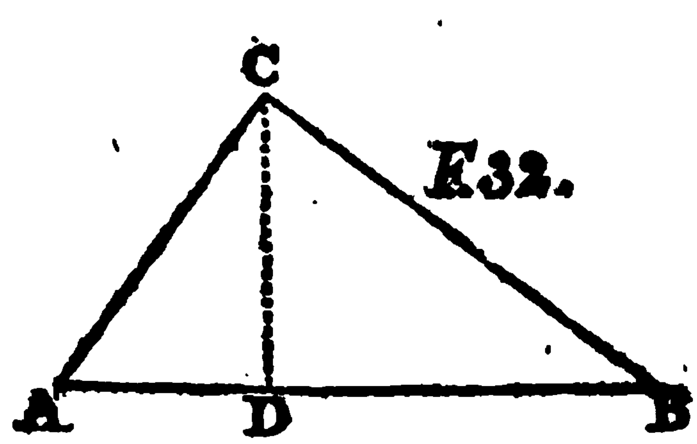
In describing the circle and its properties (*Geometry*, fig. 14) it was stated that, if from C the centre, the radius C S be drawn to

the point S in the circumference, and dividing the quadrant H S B into two equal parts, each must of course contain the half of 90, or 45 degrees: let also C S be produced until it meet the tangent B D in the point T: from S draw S B joining the extremities of the arc S B, and also S L perpendicular to the radius C B. We have now these lines belonging to the arc S B, that is to the angle S C B, namely, C S or C B the radius, S B the chord, S L the sine, S M the co-sine, B T the tangent, and C T the secant of an arch, or an angle of 45°. Now, let the three lines C S, S B, and B C form a triangle C S B; if we make the other angular points B and S the centres of circles or arcs, we may obtain other sets of similar lines, greater or smaller in proportion to the angle to which they severally belong: and hence it will follow that the sides of triangles must bear a certain proportion to the opposite angles.

If in a right-angled triangle, as A B C, fig. 31, from the angle at A as a centre, with the base A C for radius, an arc C c be described, the perpendicular C B will be the tangent, and the hypothenuse A B, will be the secant of the angle B A C. Similar effects will be produced by making the perpendicular B C the radius. On the other hand, if the hypothenuse A B be made radius, the sides A C, and C B, will become the sines of the angles to which these sides are respectively opposite.



Again, in all oblique-angled triangles, such as A C B, fig. 32, the sides are to each other in the proportion of the sines of the angles respectively opposite to each: that is to say, the side A C is to the side C B, as the sine of the angle at B, opposite to A C, is to the sine of the angle at A, opposite to C B; and the side A B is to the side A C, as the sine of the angle at C, opposite to A C, is to the sine of the angle at B, opposite to A C. From these properties it follows that, out of the three sides and three angles of which every triangle consists, if any three be given, (one of them however always to be a side) the other three parts may be discovered by calculation. [*See Article on* LOGARITHMS.]

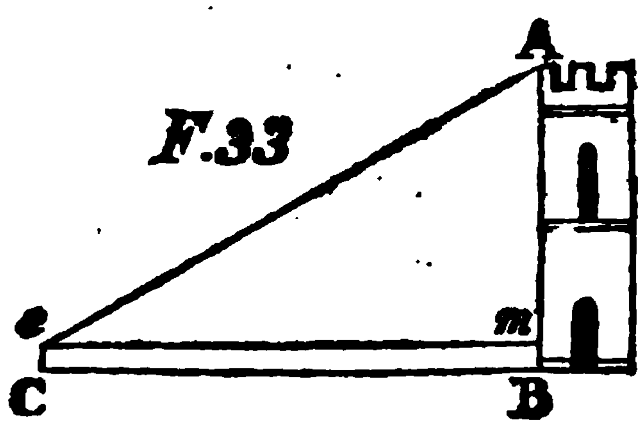


Having thus generally stated the nature of trigonometry, we may now proceed to give a short account of its application, in some

very important branches of practical knowledge, namely, in the measurement of the heights and distances of particular objects, usually, but too restrictedly called Practical Geometry, Mensuration of Surfaces and Solids, Measurement of Artificers' Work, Gauging, Land surveying, and Navigation.

Of Practical Geometry.

1st. Let A B in fig. 33, represent the wall of a tower, of which it is required to discover the height, without actual measurement.



Suppose an observer to be placed at C, with his feet on precisely the same level with B the bottom of the tower, and his eye at *e*, 5 feet from the ground: the horizontal line *e m*, will then be the level of his eye. The distance of the observer from the tower, that is C B, equal to *e m*, is measured on the ground 130 feet: and with a common quadrant or other proper instrument, the angle of the elevation of the town, that is, the angle formed by the horizontal line *e m*, and the line of sight from the eye at *e*, to the top of the tower at A, is found to be 29 deg. 59 minutes. The tower A B standing perpendicularly on the base C B or *e m*, A *e m* is a right-angled triangle, of which we know the base and the angle of elevation at *e*. If then from *e* as a centre, with the base *e m* for radius, an arc be described, *m* A will be the tangent of the angle at *e*. We have now obtained three terms of a proportion, consequently the fourth may soon be found. This proportion is as the logarithmic radius of any circle(always equal to the sine of a quadrant or 90 degrees, and for conveniency in computation always considered to be 10,) is to the tangent of the angle at $e = 29° 59'$, so is the base $e\ m = C\ B = 130$ feet, corresponding to the radius, to the perpendicular *m* A, corresponding to that tangent. Or stated in this way:

Radius	: Tangent of A *e m*	: :	Log. of *e m*	:	Log. *m* A.
Sine 90° 00′	: 29°.59′	: :	130	:	
10.00000	: 9.76115	: :	2.11394	:	
	+ 2.11394				
	11.87509				
	−10.00000				

$m\ A = 75 = 1.87509$

But the point *m* being elevated 5 feet above the bottom of the tower, equal to the height of the observer's eye at *e*, above the level line C B, that quantity must be added to the 75 feet above found; giving 80 feet for the whole height of the tower from the ground; which was the thing required to be known.

2nd. Again, let the problem be reversed. Suppose the tower A B, the height of which is known, viz. 80 feet, to be surrounded by a canal, extending from the foot of the tower to C, where an observer stands, and who wishes to know the breadth of the water. The angle of the elevation of the tower at his eye, he measures to be 29° 59′, consequently the angle at A, formed by the line A *e* to the eye, and A *m*, the wall of the tower will be 60° 01′. For all the angles of every triangle being equal to two right-angles=180°, and the angle A *m e* being itself right, it follows that the other two angles at *e* and A, must make up a right-angle between them. Subtracting therefore the given angle at *e*=29° 59′ from 90°, the remainder 60°, 01′ is the quantity of the angle *e* A *m*. Now, upon A as a centre, and with A *m* for radius, if an arc be described, the horizontal line *m e*, will be the tangent of the angle at A. Hence, as in the former case, we have this proportion: viz.

			Logarithms
As Radius	=90° 00′	=	10.00000
To Tanget of *e* A *m*	=60° 01′	=	10.23885
So A *m*	=75° 00′	=	1.87506
			12.11391
			− 10.00000
To base *e m*=C B=130		=	2.11391

This base being found 130 feet, as was given in the first case, the two operations mutually prove each other.

3rd. Let *m* A be the front wall of a building, and *m e* the surface of the ground, at right-angles to the wall: let the height of the wall be 36 feet, and the length of *e m* be 48 feet. What must be the length of a ladder, of which when the one end is placed at *e*, the other will just reach the top of the wall at A?

Upon *e* as a centre, and with *e m* for radius, if an arc be described, *m* A (as was before shown) is the *tangent* of the angle at *e*. Again, on the same centre *e*, with *e* A for radius, if an arc be described, *m* A will become the *sine* of the same angle. Hence we have the following proportions.

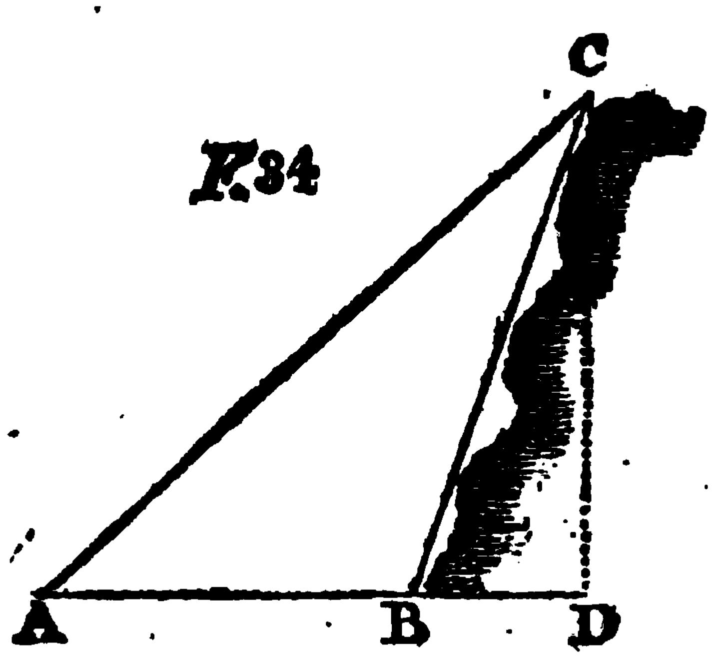
			Logarithms
As *e m*	48	=	1.68124
To *m* A	36	=	1.55630
So Radius	90° 00′	=	10.00000
To Tangent of A *e m*	36° 52′	=	9.87506

Also as Sine of A *e m*	36°,52′	=	9.77812
To Radius	90°,00′	=	10.00000
So *m* A	36	=	1.55630
To *e* A	60	=	1.77818

The length of the ladder required.

These operations however, although strictly geometrical, are tedious: it is better therefore, in all cases where two of the three sides of right-angled triangles are given, to check at least, if not to supersede them, by the method formerly pointed out in the Mensuration of triangles, where it was stated that, in all right-angled triangles, the square of the hypothenuse is always equal to the sum of the squares constructed on the two other sides. Now, in the case here given, if to the square of *m e*=48=2304, we add the square of *m* A=36=1296, and of the sum 3600 we extract the square root, we obtain 60 feet, as before, for the length of the ladder to reach from *e* to A.

4th. Let it be required to measure the elevation of a lofty precipice represented by B C, fig. 34, the true perpendicular height of which is the dotted line D C. This can be done only by observations from two stations: the one at B, as near as convenient to the precipice, and the other at A, on the same level, but farther removed from the foot of the precipice. Let the angle of elevation of the summit C, that is the angle D B C, be observed at B, to be 68° 30′ and the angle of elevation observed at A, or D A C, be 38° 00′; and the horizontal distance between the stations A and B, be measured 150 yards. The two triangles A C D and B C D, being both right-angled, if from 90°, we subtract the given angle C B D=68°, 30′, the remainder will be B C D=21° 30′: again, from 90°, subtracting C A D=38° 00′, the remainder will be the great angle A C D=52° 00′. But of this great angle the part B C D, was already found to be 21° 30′; which, taken away, will leave B C A=30° 30′. We have now all the materials necessary for calculating the line C D. It was already said that the sides of oblique-angled triangles are in the proportion of the sines of the opposite angles. In the triangle A C B therefore, the side B C will be to the side B A, as the sine of the opposite angle B A C is to the sine of the opposite angle A C B: or in this way.



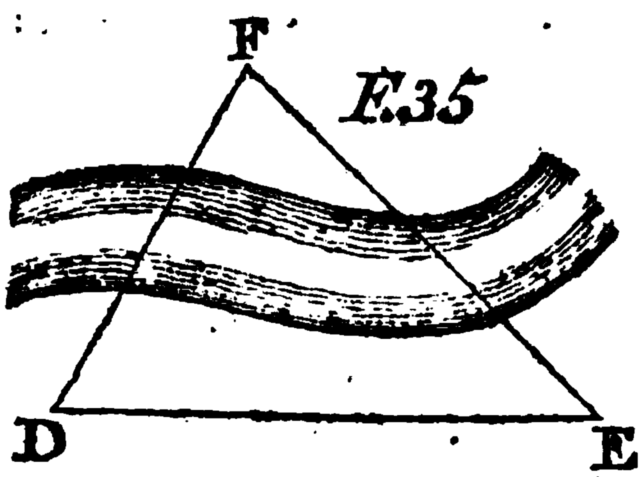
As Sine of A C B	=	30°, 30′	=	9.70547
To sine of B A C	=	38°, 00′	=	9.78934
So the side A B	=	Yds. 150	=	2.17609
To the side B C	=	Yds. 182	=	2.25996

Having thus found B C, the hypothenuse of the right-angled triangle B C D, of which the angles are also known, making B the centre, and B C the radius of an arc, C D becomes the sine of the angle at B: hence,

As Radius	=	90°, 00′	=	10.00000
To Sine of C B D	=	68.30	=	9.96868
So Hyp. B C	=	182	=	2.25996
To Perpend. D C	=	Yds. 169	=	2.22864

The required height of the precipice B C=507 feet.

5th. Let F, in fig. 35, be a tree, a steeple, or other object on one side of a river, and D and E two stations on the opposite side: it is required to calculate the distance of the object from these stations, without measuring across the river. At D observe the angle E D F, formed by lines to the object, and the other station =58° 00′, and the corresponding angle F E D=43°, 30′: let the distance between the stations of observation, D and E, be 560 yards. The three angles of the triangle D F E being equal to two right-angles,=180°, if from this quantity we subtract the sum of the two given angles at D and E, or 58° 00′+43°, 30′=101° 30′, the remainder 78°, 30′ will be the quantity of the angle D F E, opposite to the base measured between the stations D and E. Proceeding now as before, we say,



As Sine of D F E	=	78°, 30′	=	9.99119
To Sine of F D E	=	58°, 00′	=	9.92842
So given side D E	=	560	=	2.74819
To side F E	=	485	=	2.68542

Again, to find F D we say,

As Sine of D F E	=	78°, 30′	=	9.99119
To Sine of F E D	=	43°, 30′	=	9.83781
So side D E	=	560	=	2.74819
To side D F	=	393	=	2.59481

By these operations it appears that the tree or other object F, beyond the river is distant 393 yards from the point D, and 485 yards from the point E.

In these and other former examples mention is made of a *level* or *horizontal line*. By such a line we usually understand one carried at right-angles to a plummet-line hanging perpendicularly, and extended at pleasure in both ways, preserving the same straight direction. This however is a material error: for a line running N. and S. at right angles to the line of a plummet at London, in N. lat. 51½°, will not lie in the same horizontal direction with a similar line at Edinburgh in N. lat. 56°. The difference of latitude between these two towns being 4½°, or $\frac{1}{20}$ part of the quadrant from the equator to the N. Pole, if the line of the plummet from London were continued to the centre of the earth, it would there meet the corresponding line from Edinburgh, forming an acute angle of 4½ degrees. But as it is the property of parallel lines, never to meet however far extended: of course lines which do meet cannot be parallel; and consequently no right line can be drawn which shall cut them both at right angles. Hence it follows that a level or horizontal line on one point of the earth's surface, will not coincide with a level or horizontal line drawn at any other point. The direction of plumb-lines, suspended over different parts of the surface of the earth, towards its centre, precisely resembles that of the spokes of a coach-wheel to the centre of the nave: and by observing such a wheel it will be evident, that a ruler placed on the rim, at right angles to the direction of one spoke, will never touch the rim at any other point, nor consequently be perpendicular to the direction of any other spoke. But although all this be strictly and geometrically true; yet in the practice of drawing a horizontal or level line, much will depend on its extent: for such is the magnitude of our globe that even on a line of nine chains (or the 9th part of a mile) in length, the true level differs from the apparent only $\frac{1}{10}$ inch; in 13 chains (the 6th of a mile) they differ ¼ inch in 16 chains (⅓ of a mile) ⅓ inch; in 20 chains (¼ mile) ½ inch;; in 29 chains 1 inch; in 40 chains (½ mile) 2 inches; in 60 chains (¾ mile) 4½ inches; and in 80 chains or 1 mile, 8 inches. In a stretch of ten miles of the same straight line, the difference between the true and the apparent level will be 66 feet or 1 chain. The effects produced by the curvature of the surface of the earth may be rendered useful in other ways also, as in the following case. A ship at sea and making for the land in the night-time discovers

just appearing upon the face of the water, a light-house on the land. The light itself is known to be elevated 305 feet above the surface of the water. In this case it is required to determine the distance of the ship from the land at the light-house. The line of sight is a tangent to the radius of the earth at the position of the ship. The radius of the earth is, at a medium, 3438 nautical or geographical miles, the only measures employed in sea affairs. To this quantity add the height of the light 305 feet, or $\frac{5}{100}$ parts of a mile: square the sum, and from the product subtract the square of the radius; the difference will be 343.8. Of this extracting the square root we obtain 18½ nautical miles for the distance of the ship from the light-house.

In this calculation it is to be observed that no allowance is made for the refraction of the atmosphere, nor for the elevation of the observer's eye above the water, by both of which circumstances the light will appear much sooner than it ought; and consequently the ship's distance will appear to be sensibly less than it really is; but this is always to err on the safest side for the mariner.

CHAP. IX.

MENSURATION, OR MEASUREMENT OF SURFACES AND SOLID BODIES, &c.

I. Mensuration of Surfaces.

IT was already noticed that all bodies contain three kinds of dimension, namely length, breadth, and depth, height, or thickness. In the measurement of surfaces, length and breadth only are considered: in that of solids the third dimension must also be employed. The nature of mensuration will be easily understood from the following explanation. Let A C D B (Geometry, Fig. 8) be a geometrical square, that is, having all its sides equal and all its angles right. Divide A B and A C into any number of equal parts as in this case into four. Through the points 1, 2, 3, draw lines parallel to the adjoining sides, which by their intersections will divide the surface of the square into sixteen small squares, the side of which is one of the four parts into which the side of the great square is divided. If the great square be 4 inches a side, each of the small squares will be 1 inch a side. But 16 is the product of 4 squared or multiplied by itself, consequently the area or superficial contents of any square will be equal to the product of a side multiplied by itself.

1st. To find the superficial area or contents of a square, multiply the side into itself, when the product will be the answer; as for example, how many square feet of deal boards in a square floor 18 feet 6 inches each side?

ft. in.	feet	ft. in.
18 6	18.5	18 6
18 6	18.5	12
324	92 5	222
18 3	1480	222
342 f. 3 in.	185	444
	ft. 342.25	444
	12	444
	in. 3.··	144) 49284 (3
		342 f. 3 in.

Here the square is found in three different ways, by cross multiplication, by decimals, and by reduction; and the product of all is the same.

2nd. To find the area of a right-angled parallelogram such as A C D B, fig. 10, multiply the length A B or C D 35 feet 3 inches by the breadth A C or B D 15 feet 9 inches, and the product will be the superficial contents.

ft. in.	feet		
35 3	35.25	15 9	35 3
15 9	15.75	12	12
525	176 25	189	423
30 2¼	2467 5		189
	17625		
555 f. 2¼ in.	3525		3807
			3384
	ft. 555.1875		423
	12		144) 79947
	in. 2.25··		feet 555 2¼
	12		
	3.··		

3rd. To find the area of a rhombus, or distorted square, as A C B D in fig. 9, multiply the base as A B by the length of the perpendicular let fall upon it from the opposite angle as C E. Let A B be 48 feet 8 inches, and C E be 41 feet 9 inches, required the area of the figure.

ft. in.	feet	ft. in.
48 8	48 8	41 9
41 9	12	12
1968	584	501
63 4		584
6		584
ft. 2031 10		29200
		144) 292584
		ft. 2031 10

4th. The area of a rhomboides or distorted parallelogram, as A C D B, fig. 11, is found in the same way, by multiplying the base A B, supposed 685 yards long, by the perpendicular C E, 255 yards, which will produce 174675 square yards.

Had this figure been right-angled as Fig. 12, the area produced by the multiplication of A B by the perpendicular side A C, measuring 298 yards, would have been 204130 yards. In the same way the square constructed upon A B fig. 9, would have contained 2368 feet 5⅓ inches square measure.

5. To find the superficial contents of a right-lined triangle. This may be done in various ways: 1st, multiply the base, as A B in fig. 5, by one half of the perpendicular altitude C D: 2nd, or multiply one half of the base A B into the whole perpendicular: 3rd, or multiply the whole base by the whole perpendicular, and take one half of the product. Let the base A B be 24, and the perpendicular C D be 32; then the calculations are as follow.

A B = 24		½ A B = 12		A B = 24
				C D = 32
½ C D = 16		C D = 32		2) 768
384	=	384	=	384

In these cases we have supposed the perpendicular to be known by actual measurement, or by calculation: but as in general the sides only of triangles are given, and the perpendicular must be discovered, it will be requisite in this place to show how this is performed. It is the property of a perpendicular upon any line to form two equal, and consequently two right-angles: the angles A D C and C D B, in fig. 5, are therefore right, and the triangles represented by those figures are each divided by the perpendiculars into two right-angled triangles, D A C and D B C. It is further the property of a right-angled triangle, that the square constructed

or computed upon the hypothenuse, is always equal to the sum of the squares constructed or computed upon the base and the perpendicular: consequently the square of A C is equal to the sum of the two squares of A D and D C: if therefore from the square of A C we subtract the square of the base A D, the remainder will be the square of the other side C D. In isosceles triangles, or those having the angle, from which the perpendicular is let fall, formed by two equal sides, as in fig. 5, the perpendicular will fall precisely in the middle of the base, therefore the sides of the triangle being given, A D the half of A B will also be known: we have then only to square A C and A D, and extract the square root of the difference between them, which will be the length of the perpendicular C D, with which to calculate the area of the triangle. For example, let A B be 24, and A C and C B be each 28: then A D must be 12.

A C = 28	A D = 12	C D = 25.29
28	12	½ A B = 12
784	144	303.48 area of the triangle.
144		
Sq. of C D = 640 (25.29 = C D.		
4		
45) 240		
225		
500) 1500		
1004		
5149) 49600		

This process is however applicable only to triangles in which the perpendicular is drawn from an angle formed by two equal sides: in all other triangles, such as that in fig. 32, where the sides A C and C B are unequal, and where of course the perpendicular C D will not fall in the middle of A B, but nearer to A than to B in proportion as A C is shorter than C B, a different proceeding is to be adopted. It is a property of all triangles, that if a perpendicular be drawn to any of the sides from the opposite angle, as from C to A B, it will touch A B in the point D in such a way, that the whole base A B will be to the sum of the two other sides, A C + C B, as the difference between the same sides, A C − C B, is to the difference between the portions or segments of the base, separated by the perpendicular, or A D − D B. Let A B be 62 feet, A C 32, C B 45: then state this proportion, as the base A B to the sum of the sides A C + C B, so A C − C B to A D − D B; thus,

AB : AC+CB : : AC−CB : AD−DB
62 : 32+45 : : 32−45 :
+ 45 − 32

62 : 77 : : 13 :

62 : 77 : : 13
13

62) 1001 (16.145
62

381
372

90
62

280
248

320
310

10

By this operation we find the difference of length between the segments of the base A D and D B, to be 16,145 feet. It is a maxim in arithmetic and geometry that, when the sum of any two numbers or quantities is given, and also their difference, if to half the sum we add half the difference, we obtain the greatest quantity, or if from half the sum we subtract half the difference, we obtain the least.

The half of A B=62 is 31, and the half of difference just found=16.145 is 8.0725: these two added together will give 39.0725 for the greatest segment D B, opposite to the greatest side C B: or if from the half of A B=31, we take half the difference found=8.0725, we have 22.9275 for the least segment A D, opposite to the least side A C.

The great triangle A C B is now divided by the perpendicular C D into two triangles, both right-angled, A C D and D C B, of which two sides are now known, and the third may readily be found.

In the triangle A C D we have A C given 32 feet, and A D now found 22.9275: from the square of A C, subtract the square of A D, and the square root of the remainder, extracted as shown when treating of arithmetic, will be the perpendicular or other side C D.

A C=32
32

64
96

1024.
525.67025625

C D
498.32974375 (22.3233
4

42) 96
84

A D=22.9275
22.9275

1146375
1604925
458550
2063475
458550
458550

525.67025625

```
443) 1432
     1329
     ----
4462) 10397
       8924
      -----
44648) 147343
       133929
       ------
446462) 1341475
        1339389
        -------
        ...2086
```

Having thus found the perpendicular C D, if it be multiplied, as in the preceding case, by half the base A B or 31, the product will be the contents of the triangle A C B.

The same perpendicular would have been found if, instead of the triangle A C D, the triangle D C B had been employed; as the reader, by a similar process of calculation may readily discover.

```
Perp.        22.3233
½ Base           31
             -------
             22 3233
            669 099
            --------
Square feet 692.0223
```

When the three sides of a triangle are given, the area or superficial contents may be found by the following arithmetical operations. Add together the three sides: from the half of this sum subtract each side separately: multiply this half sum by one remainder, the product by another remainder, and this second product by the third remainder: extract the square root of the last product, which will be the area of the triangle. Let this be done with the triangle A C B, fig. 32.

```
A C=32        69.5        69.5        69.5
C B=45     A C=32.     C B=45.     A B=62.
A B=62      ----        ----        ----
   --       37.5        24.5         7.5
 2) 139
   ----
   69.5

      ½ Sum of sides = 69.5
      1st remainder  = 37.5
                      -----
                      34 75
                     486 5
                    2085
                    -------
                    2606.25
      2nd remainder = 24.5
                    -------
```

```
                13031 25
               10425 00
               52125 0
               ---------
               63853.125
3rd remainder  =   7.5
               ---------
               31926 5625
              446971 875
              ----------
              478898.4375 (
               . . . . . .

                                Area
              478898.4375(692.0249 nearly
              36
              --
         129) 1188
              1161
              ----
        1382)  2798
               2764
               ----
      138402)  344375
                276804
                ------
     1384044)   6757100
                5536176
                -------
    13840489) 122092400
              124564401
              ---------
```

The area by this method comes out a little greater than by the former, because in the calculation of the length of the perpendicular, a small remainder was lost.

6th. To find the contents of a trapezium or figure of four unequal sides, such as A C D B in fig. 13. Draw the diagonal A D, and upon it let fall perpendiculars from the opposite angles at C and B: take half the sum of these perpendiculars, and, multiplying it by the diagonal, the product will be the area. The same result will be drawn if the diagonal C B be employed, and the perpendiculars be let fall upon it from the angles at A and D. On the other hand, if the four sides and a diagonal be given, the area of the two triangles into which the trapezium is divided may be found as in the preceding example. Let the sides be A B = 31, A C = 26, C D = 23, and D B = 21; the diagonal A D = 32, the perpendicular from C = 18.5, and that from B = 19. The half of these the sum of these perpendiculars, or 18.75 multiplied by the diagonal 32 gives 600 for the contents of the trapezium. Again, if the other diagonal C B be employed, its length is 38.46, and the perpendiculars from A = 19.6 and from D = 11.6: half their sum = 15.6 multiplied by the diagonal C B = 38.46 will give 599.976, agreeing within an extremely minute difference of the 600 found by means of the other diagonal.

When the trapezium is of such a nature, like A C D B fig. 12, that although the sides are all unequal yet one of them as C D is parallel to another A B, the area may be found in a different way, which is this: add together the parallel sides C D = 22 and A B = 34, and take half the sum or 28 for the medium length of the figure or *n r*: take also the nearest distance between the parallel sides = 19.5; the product of these quantities multiplied together = 546 will be the contents of the trapezium.

7th. From what has been said it will be obvious that, right-lined figures, of whatever shape or number of sides, may be measured with equal accuracy and facility, by dividing them into triangles, by lines drawn from angle to angle, or to a point assumed at pleasure in the middle of each figure. Thus the irregular figure, a large common or estate, shown in fig. 36, may be thrown into triangles by the dotted lines across it from corner to corner F D, F C, F B, B K, B I, I F, and I G, in which case the number of triangles will be always *less by two* than the number of sides: thus the sides of fig. 36 are ten; but the triangles are only eight. In the same way if the field represented in fig. 37, were divided into triangles by lines from angle to angle, their number would be five, because the sides are seven. On the other hand, if the figure be thrown into triangles, by lines drawn to each angle, from any point chosen within the figure, as S in fig. 37, the number of triangles will be always *equal* to the number of sides. The areas of the several triangles however constructed will, when added together, show the contents of the given field or estate. In regular polygons we have only to calculate the contents of one of the triangles into which they may be divided by lines drawn from the centre, as represented in fig. 29 and 30, and to multiply this quantity by the number of triangles in the figure which in this case, as has just been said, is always equal to the number of sides. Or the perimeter that is the circumference of the regular polygon multiplied by the half of the perpendicular let fall from the centre upon a side, and the product will be the contents. Thus for instance let A D E F G B, fig. 29, be a regular hexagon, divided into six triangles by lines from the centre C: these triangles must be all equal, for their bases are the equal sides of the hexagon, and their other sides are so many *radii* of the same circle. Let A B the side of the hexagon be = 100 feet; then the perpendicular C *x*, calculated as pointed out in section five of this subject, will be 86.6 feet: the half of this = 43.3 multiplied by the base A B = 100, gives 4330 square feet for the contents of one triangle A C B, which again multiplied by 6, the number of triangles in the hexagon will give 25980 square feet for the contents of the whole figure. Again, one side being = 100 feet, the six sides, or the perimeter of the figure will be 600 feet, which multiplied by 43.3 the half of the perpendicular C *x*, will give the same quantity as before, 25980 square feet.

These rules are strictly and geometrically accurate: but to save time and trouble the following table has been calculated by which the contents of various polygons may be very speedily ascertained.

No. of sides	Multipliers
3	0.4330127
4	1.0000000
5	1.7204774
6	2.5980762
7	3.6339124
8	4.8284271
9	6.1818242
10	7.6942088
11	9.3656399
12	11.1961524

The table is used in this way: square the given side of the polygon, and multiply it by the number placed opposite to the figure expressing the sides of the polygon; when the product will be the area required. For example, the side of the hexagon, fig. 31, is 100 feet, which squared will be 10,000; and this again multiplied by 2.5980762 corresponding to 6 the number of sides will give 25980.762 square feet for the area of the hexagon, as before calculated.

9th. From observation of the foregoing table the reader will perceive that the number by which the square of the side of any polygon is to be multiplied, and consequently that the area of the polygon will increase proportionably to the number of its sides. From the same observation it will also be evident that the areas of regular polygons described within the same circle must likewise increase as the number of their sides is augmented. Following up this idea it will be plain that the nearer any polygon approaches to a circle, which can happen only by a continual increase in the number of its sides, the greater must be its area; and consequently that the circle itself must be always greater than any figure, of however many sides it may be supposed to consist, inscribed within it. It is true that mechanically, by means of a piece of cord, we can measure the circumference of a circular piece of timber: but in geometry we can consider the distance from one point to another, however minute, and even imperceptible by our senses, as measured in a straight line. Hence the geometrician can consider the circle only as a regular polygon of an infinite, that is an unlimited number of sides. Suppose a polygon of one thousand sides to be drawn within a circle of five inches diameter; the sides would certainly be imperceptible to the sharpest eye, but they are not on that account the less real: if from the extremities of a side lines were drawn to the centre of the circle containing the polygon, these with the side would constitute a triangle, as in the hexagon fig. 29, and the octagon fig. 30: but the base of this triangle, which is the side of the polygon would, in the instance supposed, bear so small a proportion to the sides, that the perpendicular drawn from the centre to its middle point might be considered as equal to either of the sides, that is to the radius of the circle. But it was before shown that the contents of all regular polygons are the product of their peremiter or circumference multiplied by half their perpendicular: consequently the contents of a circle are the product of the circumference multiplied by half the radius, that is

to say by one fourth part of the diameter; or of half the circumference by half the diameter, or of the whole diameter by one fourth of the circumference. But as the circle which incloses a polygon of however great a multitude of sides must always be greater than that polygon, the area found by these operations must always be something less than the truth.

To ascertain the proportion between the radius or the diameter of a circle and its circumference, the efforts of ingenious men were very early directed. Archimedes the celebrated geometrician of Syracuse in Sicily, who was born about 280 years before our Saviour, determined that if the diameter of a circle were 7 feet the circum. would be very nearly 22 feet: so that to ascertain the circumference of any other circle, as one of 25 feet diameter, it would only be necessary to solve this proportion, as 7 to 22, so 25 to a fourth proportional, namely 78.57. This rule will answer with sufficient accuracy, in a rough way, in circles of small diameter: but if the diameter were 800 feet, the circumference calculated in this way would be one foot more than it ought to be, that is 2514 instead of 2513 feet. Another proportion much nearer to the truth was published by a German geometrician, Adrian Metius, which is, that if the diameter be 113 the circumference will be 355: a proportion so near, although more than the truth, that if the diameter of a circle were one million of feet, nearly 190 English miles, the circumference would exceed the truth by only 3 inches. The proportion subsisting between the diameter and the circumference of all circles has however been ascertained with the closest approach to absolute accuracy to be this, that if the diameter of a circle be 1 inch, foot, yard, mile, &c. the circumference will be 3.14159265358979, or in common practice as 1 to 3.14159. This calculation was carried on, by long and incessant labour, to many places of decimals, without ever obtaining a conclusion without a remainder, and consequently without arriving at absolute arithmetical certainty, by the eminent Dutch geometrician *Van Keulen* of Leyden; and as a memorial of his perseverance and ingenuity, the result of his assiduous toil was engraved on his tomb.

Having thus briefly explained the nature of the circle, we may proceed to give some instances of the method of computing its superficial contents.

The radius with which a circle is described is 15 feet, required its circumference and contents.

	Radius =	feet 15	
		2	
1 : 3.14159 : :	Diameter =	30	
30			
Circumference 94.2477	$\frac{1}{2}$ circumference	=	47.12385
	$\frac{1}{2}$ diameter	=	15
	area	=	706.85775 sq. ft.

or thus: Circumf. = 94.2477
½ Diameter = 7.5

4712385
6597339

Area 706.85775

or thus: circumf. = 94.2477
diam. = 30

4) 2827.4310

area 706.8575

When the circumference of a circle is given the proportion is reversed and the given circumference is divided by the standing number 3.14159. Required the diameter, the radius, and the contents of a circular plot of grass, measuring in circumference 856 yards.

3.14159) 856.00000 (772.473 yards diameter
628 318
227 6820
219 9113
7 77070
6 28318
1 487520
1 256636
2308840
2199113
1097270
942477
154793

2)
772.473
136.2365 = radius

½ diam. = 136.2365
½ circumf. = 428

1089 8920
2724 730
54494 60

area 58309.2220

The circumference of the globe of the earth, like every other circle, is divided into 360 degrees. The earth not being a perfect sphere, but greater in circumference from east to west, than from north to south, this greatest circumference is computed to be about 24,930 English miles, consequently each degree will contain 69¼ English miles. The diameter of this greatest circuit, which is at the equator, equally distant from both poles, will therefore, by the rule here given, be 7935.49 miles, the quotient of the circumference 24930 divided by 3.14159: and this diameter multiplied by one fourth of the circumference, or by 6232.5, will give 49457941.425 square miles for the superficial contents of a circle equal to that which would be exhibited, if the earth were cut into two equal portions, by a plane passing through the equator and the centre of the globe.

9th. In speaking of the nature of the circle it was observed that, any portion of a circle as S C B in fig. 14, comprehended between the arch S B, and the two radii S C and B C, is called a

sector; as being cut into the body of the circle. The arch of this sector being described by the same radius with the circle itself, it is evident that its area must bear to that of the whole circle that precise proportion which the arch S B bears to the whole circumference B O K A H S. Let the arch S B contain 45 degrees of a circle, whose whole circumference measures 856 yards. What will be the contents of the sector S C B? In the foregoing article it was found that the diameter of such a circle would be 272.473 yards, and consequently the radius, as C B and C S 136.2365 yards; and therefore, that the area would be 58309.222 square yards. We have then this proportion, as the whole circumference of the circle=360° to its area, so is the arch S B=45° to the area of the sector.

```
Deg.      Sq. yards       Deg.
360  :   58309.222 : : 45 :
                45
         -----------
         291546 110
        2332368 88
        -----------      Sector.
 36|0)  2623914.99|0(7288.65275
         252              Sq. yards.
         ---
         103
          72
          --
          319
          288
          ---
          311        99
          288        72
          ---        --
           234       270
           216       252
           ---       ---
            189       180
            100       180
            ---       ---
             99       ...
```

Again, as 45° are one eighth part of 360°, we may take at once the eighth part of the area of the circle for that of the sector, which will give the same answer as before.

```
  8)58309.222
  -----------
Sector=7288.65275
```

Again, as by multiplying half the circumference into half the diameter, we obtain the area of a circle, so by multiplying half the arch of the sector into the radius, we obtain the area of that portion of the circle. But the circumference of the circle being given 856 yards, the arch of 45° must measure ⅛ or 107 yards, which multiplied by half the radius=68.11825 will give, as in the two preceding operations, 7288.65275 square yards for the area of the sector.

10th. A segment of a circle, it was formerly stated, is a portion of a circle cut off by a chord or right line joining the two extremities of any arch. Thus, in fig. 14, the line A H joining the

the extremities of the arch or quadrant A Z H, cuts off a portion of the circle or the segment A Z H. If from the extremities A and H, lines be drawn to the centre as A C and H C, then will the figure A C H Z be a sector of the circle. But the line A H, forming the segment, also cuts off a portion of the sector, leaving the triangle H A C. If therefore, we find the contents of the whole sector A Z H C, and from it subtract the contents of the triangle H A C, the remainder must be the contents of the given segment A Z H. Let A Z H C be a quadrantal sector, and consequently the fourth part of a circle of which the circumference is 314.159 feet; the arch A Z H of 90° will then contain 78.58975 feet, and each radius C A or C H will be 50 feet. In this case the area of the whole circle will be 7853.975, and that of the quadrantal sector, 1963.49375 square feet. The triangle A H C being right-angled at C, and the base and perpendicular A C and C H being each 50 feet, 50 multiplied by 25 = 1250 feet, are the contents of that triangle, which, subtracted from the contents of the whole sector, will leave 713.49375 square feet for the contents of the segment A H Z required to be measured.

11. To measure the area of an oval or ellipse, such as in fig. 15 and 16. Multiply the longer by the shorter axis, and extract the square root of the product, which will be the diameter of a circle equal in area to the given ellipse. For instance, let A H C L B D be an ellipse of which the longer or transverse axis A B measures 36 inches, and the shorter or conjugate axis C D measures 26 inches: the contents in square inches of the ellipse are required.

A B = 36	3.14159
C D = 26	Diameter = 30.594
216	1256636
72	2827431
— Diameter	1 570795
936 (30.594	94 24770
9	
605) 3600	Circumf. = 96.11380446
3025	½ Diam. = 7.6485
6109) 57500	48056902230
54981	76891043568
61184) 251900	38445521784
244536	57668282676
7364	67279663122

Area of circle equal to ellipse = 735.126433412310

Hence it follows, that the area of an oval or ellipse is always one half of the sum of two circles described upon its greater and less axis.

12. To find the superficial contents of a perfect sphere or globe, you multiply the whole circumference into the whole

diameter; because the surface of a globe is always equal to four times the contents of a circle of the same diameter. In article 8, the area of a circle whose diameter is equal to that of this earth, supposing it a perfect sphere, that is equally circular in every direction, would be 49457941.425 square English miles: if this be multiplied by 4, we obtain the number of square English miles contained in the whole surface of the earth, supposing it regular and even, =197831765.7: equal to the product of the whole circumference 24930 miles, multiplied by the diameter 7935.49 miles.

II. Mensuration of Solids.

By a solid body we understand, not the impenetrability or hardness of any substance, but a body capable of measurement in length, breadth, and thickness, height or depth. Thus we speak of the solid contents not only of a block of stone, or a log of mahogany, but of a pond of water, and of the air in a chamber, estimated by the above three dimensions. As a square of some determinate magnitude is the measure of surfaces, so a cube is the measure of all solids. If we draw a square each side of which is an inch, we form a square inch; and if upon this surface we raise a solid body with perpendicular sides, and an inch in height, we have a solid inch. Were a pair of dice to be made an inch long every way, they would be perfect examples of solid inches. If a square surface measured one foot or 12 inches each side, by multiplying the one into the other, we obtain one square foot or 144 square inches; and if on this surface a cube were erected also one foot or 12 inches in height, by multiplying the square surface by the height, we should obtain one solid foot or 1728 solid inches.

1. To find the solid contents of a cube of which each side measures 6 feet or 72 inches.

Ft.	In.	Inches
Side=6	72	Inches in 1 foot=1728
6	72	Cubic feet= 216
—	—	—
Square=36	144	10368
6	504	1728
—	—	3456
Cube=216	5184	—
	72	Cube=373248
	—	
	10368	
	36288	
	—	
	Cube=373248	

2. A solid body may have its breadth and height equal; but if its length be either greater or less than these, it ceases to be a cube, and is termed a *parallelopiped*: and its solid contents are found by multiplying the surface of one end by the length of the

body. Thus a log of mahogany properly squared, is in breadth and depth 33½ inches, and in length 24¼ feet; how many solid feet does it contain?

```
                  Inches                      Feet
             Breadth=33.5              Length=24.25
               Depth=33.5                       12
                  ------                    ------
                   16 75               Inches 291...
                  100 5
                 1005
                 -------
             End=1122.25
                     291
Inches 12        -------
       12        1122 25
       --      101002 5
      144      224455
       12      -------- feet solid.
     1728)     326579.75 (188.99
               1728
               ----
               15377
               -----
               13824
                15539
                13824
                -----
                 17157
                 15552
                 -----
                  16055
                  15552
                  -----
                    503
```

If the solid body be formed by four unequal sides, the area of its end or of a section across it, must be found as directed in article 6; and that multiplied by the length will give the solid contents.

8. When the end of a regular solid body is a triangle, or when it contains any number of sides more than four, as a pentagon, an octagon, &c. it is not called a parallelopiped, but a *prism*: and its solid contents are found as before, by finding the area of its end or base, and multiplying it by its length or height. Thus, a regular prism of eight equal sides, each 12 inches, is in length 36 feet, how many solid feet does it contain? The side 12 squared is 144, which, multiplied by the number opposite to 8, the number of sides in the table at the end, art. 7, gives for the area of the octagonal end 695.29 inches; and this quantity multiplied by the

length 36 feet or 432 inches, gives 300366.792 solid inches, which divided by 1728 the solid inches in a foot cube are equal to 173 feet, and 1425 inches solid.

4. A cylinder is a regular solid on a circular base and of the same diameter throughout, such as a roller for a garden or a field. It was before said, art. 8. that a circle is in geometry considered as a polygon of an infinite number of sides, consequently a cylinder can be considered only as a prism of an infinite number of sides. To find the solid contents therefore of a cylinder we multiply the area of the circular end or base by the length, and the product is the solid contents required. The diameter of a stone roller for a garden is 17½ inches, and its length is 4 feet 9 inches; what is its solid content?

```
           3.14159        circle      = 54.997825
Diam.    = 17.5           ¼ diameter  =     4.375
         ---------                    -------------
          15 70795                     274 989125
         219 9113                     3849 84775
         314 159                     16499 3475
         ----------                 219991 300
Cir. = 54.977825                   ---------------
                                    240.615484375 area of end.
                                               57
                                   ---------------
                                   1684 308390625
                                  12030 77421875
                                  -----------------
                             feet 13715.082609375 solid contents.
```

5. If upon a circular base a figure be constructed drawing regularly to a point, it becomes a *cone*, such as a sugar-loaf; but when the base is of any other shape, or of any limited number of sides, the figure ceases to be a cone, and is termed a *pyramid*. The celebrated pyramids of Egypt are enormous edifices, constructed on square or at least rectangular bases, and carried up with four regularly sloping sides meeting in a very small level space, appearing to the eye at a distance as a point, at the top. It may be shown, even mechanically that three square pyramids, all of equal bases and altitudes, may be exactly formed out of one square parallelopiped: consequently the pyramid must be one third part of the parallelopiped of the same base and height. From the relation between the pyramid and the cone, it may also be proved that a cone is one third part of a cylinder of the same base and height. To find the solid contents of a pyramid, therefore, or a cone we have only to calculate the contents of a parallelopiped or a cylinder of equal base and altitude with the pyramid and cone, and to take their third part for the solid contents required.

The greatest of the Egyptian pyramids is described as of different dimensions by different travellers: but taking the medium

of these various accounts, we may suppose it to stand upon a square base of 700 feet each side; and the inclined side being of the same extent, the perpendicular altitude of the pyramid (found as shown in art. 5 of mens. of surfaces) will be 606 feet. The superficial area of the square base 700 feet a side is 490,000 feet, which multiplied by one third of the altitude, or 202 will give 98,000,000 solid feet for the contents of the great pyramid.

Had a cone been erected on the same ground, of a diameter equal to the side of the pyramid, and of the same altitude, its contents or solidity would have been 77,738,644.55 feet. For the area of the circular base of 700 feet diameter (found as shown in art. 8 of mens. of surfaces) is 384,844.775 square feet, which multiplied by 202 the third of the perpendicular altitude of the cone, will give the above number of feet solid for its contents.

A *frustum* signifies a portion of a cone or a pyramid cut off parallel to the base. Suppose a loaf of sugar, which may be considered as a regular cone, were in diameter at the base 9½ inches, and in perpendicular altitude 21 inches: let it be cut across in the middle of its height parallel to the base: required the solid contents of the whole loaf, and of each of the portions into which it is divided? The area of the base of the loaf 9½ inches in diameter is 70.88 square inches, which multiplied by one third of the height or 7 will give 496.16 solid inches for the contents of the whole loaf. Again, if a regular cone or pyramid be cut in the middle of its length by a plane parallel to the base, the diameter of this section will be exactly one half of that of the base: the diameter of the section in this case will therefore be 4¾ inches, and the area of the section, which is the base of the small cone cut off, will be 17.72 inches, which multiplied by one third of the height of this little cone (which is one half of that of the large cone) or 3.5 will give 62.02 solid inches for its contents. This quantity subtracted from the whole loaf 496.16 inches, leaves 434.14 solid inches for the contents of the frustum of the cone next to the base. These operations will be more intelligible by a reference to fig. 5, where A C B may represent a regular cone standing on its base A B: the dotted line C D shows its perpendicular altitude, and *a b* the section across parallel to the base through the middle of the altitude: *a* C *b* is the small cone towards the top, which being taken from the great cone A C B, leaves the frustum (that is the piece broken off) A *a b* B.

6. To find the solid contents of a sphere or globe. As the circumference of a circle is considered to be a polygon of an indefinite number of sides, (art. 8 of mens. of surf.) so the external surface of a sphere or globe may be considered as composed of an indefinite number of planes, each forming the base of a pyramid the altitude of which is the radius or half the diameter of the globe. Now the solid contents of each pyramid being the product of the area of its base multiplied by one third of its altitude, the total amount of all these little pyramids must be the product of all their bases multiplied by one third of their height; or in other words the solid contents of a globe must be the product of its surface

multiplied by one third of its radius, or one sixth of its diameter. Suppose a globe or ball 37.7 inches in circumference: required its solid contents. Agreeably to the directions formerly given (art. 8, and 12 of mens. of surf.) find the area of the external surface of the ball 452.4 square inches. This quantity multiplied by one third of the radius, or one sixth of the diameter 2 gives 904.8 inches for the solid contents of a ball of 12 inches diameter. A cylinder of the same dimensions (art. 4) would contain 1357.2 solid inches; and a cube (art. 1) would contain 1728 solid inches.

N. B. The following general rule will be of use in calculating both the superficial and the solid contents of bodies of the same form, but of different dimensions. The *superficial* contents are in proportion as the *squares* of the *homologous*, that is the corresponding parts; and the *solid* contents are in proportion as the *cubes* of the same homologous parts. Thus let there be two square figures, the side of the first being 12 and the side of the other 15: the superficial contents of the first (art. 1, mens of surf.) will be 144, and the contents of the second 225: but these quantities are also the squares of the homologous or corresponding parts, that is of the sides of the given figures. Again, instead of two squares let us take two circles, the first 12 inches in diameter and the second 15. The area of the first will be 113.1 inches, and that of the second 176.7144; quantities which bear to each other the same proportion that 144 the square of 12 the diameter of the first circle bears to 225 the square of 15 the diameter of the second circle.

```
Sq. 12  Sq. 15   Area
 144  :  225  ::  113.1  :
         113.1
        ------
         565 5
        2262
       2262
       --------- area
144)   25447.5 (176.7
       144
       ----
       1104
       1008
       ----
       ··967
         864
        ----
        1035
        1008
        ----
        ··27
```

The reader, for his own satisfaction may calculate the superficial areas of any other regular figures, and he will find that they are to one another constantly in the proportion of the *squares* of their corresponding parts, sides, diameters, &c.

In the same way the solid contents of a sphere of 12 inches diameter being, as above found, 904.8 inches, the solid contents

of another sphere of 15 inches diameter will be 1767.144; quantities bearing the one to the other the same proportion that the *cube* of the one diameter or circumference bears to the *cube* of the other diameter or circumference.

III. Measurement.

The preceding rules and examples show the method of calculating the superficial and solid contents of various bodies regular and irregular: but in the application of these directions to the business of ordinary life, various practices are followed, adapted to the several kinds of bodies or works to be measured and valued.

The most common kinds of work done by artificers may be arranged under these heads, viz. 1. Bricklayers, 2. Carpenters and Joiners, 3. Glaziers, 4. Masons, 5. Painters, 6. Paviors, 7. Plasterers, 8. Plumbers, 9. Sawyers, 10, Slaters and Tilers. These different sorts of work are measured and valued in different ways: Bricklayer's work is measured by the square rod of 16½ feet, equal to 272¼ square feet:—Carpenter's, such as flooring, partitioning, roofing, also tiler's, by the square of 10 feet a side, or 100 feet, called a square:—Glazier's and Mason's flat work by the square foot:—Painter's, Pavior's, Plasterer's, by the square yard containing 9 square feet:—Plumber's work is usually computed by the weight of lead employed.—

1. Bricklayer's work. This is computed on the supposition that the wall is one brick and a half in thickness; and when it is more or less so, the thickness must be reduced to the brick and half. Thus if the wall be of the thickness of three bricks, one half of the measurement will give the quantity of work; on the other hand, if the wall be only one brick in thickness, then one half more than the measurement must be added to make up the true quantity. The usual way in measuring bricklayer's work, is to take the half of the measurement round the middle of the outside, and half the round on the inside, which added together give the true dimensions including the thickness of the wall. When the height of the wall is unequal, take the different heights, add them together, and divide the sum by the number of heights taken; the quotient will give the medium height. It must be remembered however, that this method is liable to great error, unless where the different heights are so balanced that the excess in one part may exactly make up for the defect in another. A chimney standing by itself, without any party wall adjoining, is measured by taking its girth for the breadth, and the height of the story for its length: but if the chimney stand against a wall you must measure round it only from wall to wall, for the breadth. Shafts of chimneys rising above the roof are girt about for the breadth, if they be only 4 inches thick they are reckoned as a brick, and if 9 inches, as brick and half, on account of the scaffolding and plastering. A deduction is made for materials only, and not for labour, for doors, windows, niches, &c.; and allowances are granted to the workman for returns or angles of walls, for feathered gables, ornaments, &c. The rod of

brickwork strictly contains 30¼ square yards, or 272¼ square feet: but in practice it is customary to count only 272 feet in the rod. To compute the quantity of bricklayer's work, multiply the superficial feet in the wall by the number of half-bricks in the thickness, and divide the product by 3; the quotient is the contents required.

Example 1. How many rods of brickwork in a wall 125 feet 6 inches long, by 22 feet 8 inches high, and 3½ bricks thick.

By Duodecimals

```
            Ft.  In.
Length      125   6
Height       22   8
            ---------
           2750
             83   4
             11   4
            ---------
           2844   8
Half-bricks       7
            ---------
        3) 19912  8
            ---------
           6637   7
272  3  12
 12 ------          R.  Y.  F.
3267) 79651 (24    11   4½
      6534
      -----
      14311
      13068
      -----
   108) 1243 (11
        108
        ----
         163
         108
         ----
     12) 55 (4
         48
         --
          7
```

By Decimals

```
           Feet
Length   125.5
Height    22.66
         ------
          75 30
         753 0
        2510
       2510
       ---------
       2843.830
              7
       ---------
    3) 19906.810 (1
       ----------- Rods
272.25) 6635.603 (24.3732
        5445 0
        ------
        1190 60
        1089 00
        -------
         101 603
          81 675
         --------
          19 9280
          19 0575
          --------
           ·· 87050
              81675
              -----
               53750

          R.   Y.   F.
          24   11   2½
```

```
     24.3732
     272.25
     -------
      54450
     81675
    190575
   81675
   -----------
9) 101.603700
   -----------
    11.2782
         9
    -------
     2.5038
```

Here 1st, by duodecimals the length 125ft. 6in. multiplied by 22ft. 8in. give 2844ft. 8in. for the superficial contents of the wall, which multiplied by 7 the half-bricks in the thickness, and the product divided by 3 the half-bricks in the standard thickness of wall 1½ brick, the quotient 6687$\frac{1}{12}$ solid feet, gives the contents of the wall in standard bricklayer's measure. This quantity multiplied by 12 to take in the remainder 7, and divided by 3267 the product of reducing the solid feet in a rod, 272¼, by 12, will give 24 rods: and the remainder divided by 108 the twelfth part of a foot in a square yard or 9 feet, will quote 11 yards: and the remainder divided by 12, will give 4⅓ feet, making the whole solid contents of the wall 24 rods, 11 yards, 4⅓feet, of bricklayer's measure.

The same operation is performed by decimals: but the result comes out a little less than the truth, on account of the fraction of height lost in converting 8 inches into a decimal fraction, which cannot be done without a remainder.

Example 2. The gable of a house rises 20 feet above the wall, which is 36 feet high by 24 feet 6 inches wide; and the wall is 2½ bricks in thickness. Required the quantity in the whole end of the house and in each part of it. The length 36 multiplied by the height of the wall under the gable 24ft. 6in. gives 882 square feet, which multiplied by 5 the half-bricks in the thickness, and the product divided by 3, the quotient 1470 is the standard feet: and this divided by 272, the feet in a rod, neglecting the fraction, gives 5 rods, with a remainder of 110 feet, which divided by 9, the feet in a square yard, will quote 12 yards and 2 feet over; making the contents of the wall below the gable, 5 rods, 12 yards, and 1 foot.

Again, the gable end is a triangle of 24ft. 6in. base, by 20ft. of perpendicular: computing this as formerly shown, (art. 5, mens. of surf.) the result will be 1 rod, 15 yards, and 1 foot: and these two quantities added together will give 6 rods, 27 yards, 3 feet square, for the measurement of the whole end wall described in the question.

2. Carpenters' and Joiners' work, such as flooring, partitioning, roofing, &c. is measured by squares of 10 feet a-side, or 100 square feet. In measuring floors no deductions are made for hearth-stones, because of the trouble and waste of materials. Partitions are measured from wall to wall, and from floor to floor. In roofing, the whole length of the timber is taken for the length of the framing, and the whole extent over the ridge, from wall to wall, is the breadth. Stair cases are measured by taking the breadth and height of all the steps, with a line applied close to the whole surface from top to bottom; which gives the length of the stair, and the horizontal length of a step is the breadth of the stair. Wainscotting is computed by taking the compass of the room for the length, and the height from the floor, for the breadth, making the measuring tape or string to ply close into all the mouldings. Out of this, deductions are made for doors, windows, chimnies, with respect to the materials; but the workmanship is counted for the whole surface, on account of the extraordinary trouble required in finishing those parts. For doors it is customary to allow for their thickness,

by adding it to both dimensions of length and breadth, and then multiplying them together for the contents. If the door be pannelled on both sides, double its measure is taken for the workmanship; and if one side only be pannelled, the measure and its half are taken for the workmanship: window-shutters bases, &c. are measured in the same way.

Example 1. How many squares are in a floor 42 feet 8 inches long, and 18 feet 9 inches broad?

	Ft.	In.
Length	42	8
Breadth	18	9
	756	
	31	6
	12	6
100)	800	0

Squares 8. exactly.

	Feet
Length	42.66666
Breadth	18.75
	2 1333333
	29 855555
	341 33333
	426 6666
Feet	799.9888183

Within a small trifile of 8 squares.

Example 2. If the roof of a house be 36 feet 6 inches long, and the breadth measured from one wall over the ridge to the other wall, be 54 feet 9 inches, how many squares will the roof contain?

	Ft.	In.	
Length	36	6	
Breadth	54	9	
	1944		
	27	0	
	27	4	6
100)	1998	4	6

19 Sq. 98 feet, 4½in.

	Feet
Length	36.5
Breadth	54.75
	27 375
	328 50
	1642 5
Feet	1998.375
	12
In.	4.5..
	12
	6..

Example 3. A room has 3 windows, each with 2 shutters, 6 feet 9 inches in height, and 2 feet 9 inches broad, pannelled on one side only: how many yards do they contain?

	Ft.	In.	
1 shutter	6	9	
by	2	9	
	12	0	
	6	6	9
	18	6	9
Shutters			6
9)	111	4	6
	12 yards, 3 feet, 4½ inches.		

3. Glaziers measure their workmanship and materials by feet, inches, and twelfth parts of an inch, and estimate by the square foot. Windows are sometimes measured by taking the dimensions and area of one pane, and multiplying that quantity by the number of panes; but the more usual way is to take the length and breadth of the whole window, over all the panes and frames, for the dimensions of the glazing. Circular and oval windows, fan lights, &c. are measured as if they were formed with straight sides and right-angles, taking for dimensions their greatest length and breadth, to make a compensation for the waste of glass, and the additional labour in cutting it to the required shape.

Example: how much glass will be required for 6 windows, each 5 feet 8 inches high, and 3 feet two inches broad?

	Ft.	In.	
Height	5	8	
Breadth	3	2	
	15		
	2	10	
		1	4
Feet	17	11⅓	
Windows		6	
Feet	107	8	

4. Masons' work comprehends all sorts of stone work; and it is measured by the foot, superficial or solid, according to its nanature. Blocks of marble or stone, columns, walls, &c. are measured, by the foot solid: pavements, chimney-pieces, &c. by the foot superficial. Solid measure is used for materials, and superficial for workmanship. In solid measure, the length, breadth, and thickness, are multiplied together for the contents: in superficial

measure, the length and breadth of each part are taken, whether on a plain surface, or projecting from the upright face of the building. All windows and doors are deducted from the contents of the walls, for the materials only: but the value of the workmanship is included in the charge at the given rate.

Example 1. Required the solid contents of a stone wall 256 feet long, 16 feet 8 inches high, and 2 feet 10 inches thick, at a medium.

	Ft.	In.
Length	256	6
Height	16	8
	4096	
	170	8
Surface	4266	8
Thickness	2	10
	8532	
	3556	4
Solidity, ft.	12088	4

5. Painters' work is measured like that of joiners and carpenters, by girting over the mouldings and swelling pannels, in taking the height, because wherever the brush and the colour have gone, and labour has been employed, a compensation ought to be made to the workman. The dimensions are taken in feet and inches, and the value is reckoned by square yards, &c: the painter however never reckons as the joiner does, by work and half, double work, &c.; but by the number of coats of colour applied, once, twice, thrice, &c. Window-lights, window-bars, railings, and works of that sort are generally done by the piece.

Example. The height of a room, pressing the measuring line into all the mouldings, is 15 feet 3 inches, and the compass of the room is 86 feet 6 inches: what number of yards of painting does it contain?

	Ft.	In.
Compass	86	6
Height	15	3
	1290	0
	29	1½
9)	1319	1½
Yards	146	5ft. 1½

6. Paviors' work is computed by the square yard.

Example. What will it cost to pave a yard of straight sides, and right angles, 146 feet long, by 96 feet 6 inches broad; reckoning the expense at 4s. 6d. per square yard of paving?

	Ft.	In.		Ys.	Ft.		S.	D.
Length	146	0		1565	5		4	6
Breadth	96	6		54			12	
	876			6260		9)	54	
	1314			7825			6	
	73	0		84510			5	
9)	14089	0		30			30	
	1565 yds. 5ft.		12)	84540 (				
			2|0)	704|5				
				£352..5				

7. Plasterers' works are principally of two sorts, plastering upon laths called *ceiling*, and plastering upon walls or partitions made of framed timber, called *rendering*. Deductions are made for doors, windows, and the like; and in measuring between quarters one fifth of the whole area is usually allowed: but when rendering between quarters is whitened, or coloured, one fifth is added to the whole, for the sides of the quarters and braces. Plasterers' plain work is measured by the square foot or foot or yard; but enriched mouldings, &c. by running or lineal measure. The quantity of work done is calculated by multiplying the length by the breadth or height, as in the preceding examples of other artificers' work.

8. Plumbers' work is done in general by the pound or the hundred weight; because no method has yet been discovered of casting sheet lead of one uniform thickness in all parts. The lead plates which line the tea-boxes from China are reduced to a thinness which, in Europe, has never been imitated. It is said to be done in this way: the caster sits by a pot containing the melted metal, having two large stones, the under one fixed, the upper one moveable, directly before him. He raises the upper stone by pressing his foot upon the side of it, and with an iron ladle pours into the opening between the stones a proper quantity of metal: then immediately letting fall the upper stone, he, by the pressure, forms the lead into a very thin irregular plate, which is afterwards cut into proper shape. The surfaces of the stones that are to press the lead are exactly ground down to fit one another.

Sheet lead is of two sorts, cast, and milled. Sheet-lead used in roofing, guttering, &c. commonly weighs from 7 to 12 pounds the foot square: but the following table shows the particular weights of a square foot of various thicknesses,

Thick.	lb in sq. ft.	Th.	lb in sq. ft.	Th.	lb in sq. ft.	Th.	lb. in sq. ft.
.1	5.899	$\frac{1}{8}$	7.373	.15	8.848	.18	10.618
.11	6.489	.13	7.668	.16	9.438	.19	11.207
$\frac{1}{9}$	6.554	.14	8.258	$\frac{1}{6}$	9.831	$\frac{1}{5}$	11.797
.12	7.078	$\frac{1}{7}$	8.427	.17	10.028	.21	12.387

The left-hand columns contain the thicknesses of the lead expressed in tenths, hundredths, or other parts of an inch, and opposite in the right-hand columns are the respective weights of a square foot. Thus the weight of a square foot of sheet-lead, one tenth of an inch in thickness is 5 pounds and 899 thousandth parts, very nearly nine-tenths;—of $\frac{1}{8}$ or half a quarter of an inch in thickness is 7.373 pounds;—of $\frac{1}{5}$ or two tenths of an inch 11.797 pounds, &c.

Leaden pipe, of an inch diameter in the bore, weighs commonly 13 or 14 pounds the yard in length.

Example. Required the weight of a covering of sheet-lead 58 feet 9 inches long, by 9 feet 8 inches broad; when the lead is one-sixth of an inch in thickness, and at an average weighs (as in the table) 9.831 pounds the foot square.

	ft.	in.
Length	58	9
Breadth	9	8
	522	
	45	5
		6
	567	11
	9.831	
	68 817	
	589 86	
	4915 5	
	9 012	
lb)	5583.189 (11	
Qrs.)	199 (3	
Cwt.	49.	
Tons	2 9 3 11	

2. Sawyers' work is commonly computed by the piece: twelve-feet deals and battens sawn are charged by the dozen of cuts, from

2sh. 9d. to 3sh. 6d. per dozen: ten-feet do. from 2sh. 6d. to 3sh. per dozen. Extra cuts are charged at the rate of 3sh. per square of 100 feet. But the charges vary in different times, and in different parts of the country.

10. Slaters' and Tilers' work. In these works the area of the roof is found by multiplying the length of the ridge by the girt from eave across to eave: and in slating allowance is made for the double row of slates at the eaves. In taking the girt the line is made ply over the edge of the lowest row of slates and turn under it till it meet the wall or eave-board: but in tiling the line is carried down to the lowest edge only, without turning under it. Double measure is generally allowed for hips, valleys, gutters, and the like; but no deductions are made on account of chimneys. In all these works the quantity is calculated either in yards of 9 square feet, or in squares containing one hundred square feet.

Example. In a roof of slate 76 feet 9 inches long by a girt of 42 feet 6 inches, how many yards?

	ft.	in.	
Length	76	9	
Girt	42	6	
	152		
	304		
	3192		
	69	6	
		4	6
9)	3261	10	6

362 yards 3 feet $10\frac{1}{2}$ inches.

12. *The measurement of Boards and Timber.*

The length multiplied by the breadth will give the superficial contents of a plank or board. When it tapers regularly, half the sum of the breadth at each end is the mean breadth to be used in the multiplication: but if the board be of various irregular breadths in different places, these several breadths must be added together, and the sum divided by the number of measures taken will give the mean breadth of the board. Thus a board is in length 26 feet 8 inches: the breadth at one end is 26 inches, at the other end 17 inches, and in three intermediate points 22, 25, and 15 inches; required the number of superficial feet in the board.

	In.	Ft. In.
Breadths	26	26 8
	22	12
	25	——
	15	320
	17	
5)	105	
Mean breadth	21 inches	
Length	320	
144)	6720	
	$46\frac{2}{3}$ feet square.	

It is to be observed however that unless the different measurements are taken at equal distances on the length, the mean breadth may be very erroneous, and give a false answer.

Solid timber.—A square piece of timber *equally thick in all parts*, is parallelopiped, and may therefore be measured as was directed for that figure, (art. 2, mens. of sol.) If it be dressed with more than 4 equal sides it becomes a prism, (art. 3:) if it be round it becomes a cylinder, (art. 4,) and if it taper regularly to a point it is either a pyramid or a cone, (art. 5:) if it be circular and taper regularly, but not to a point, it is the frustum of a cone: and in all these cases the solid contents are found as before pointed out. Regular figures of this description are not to be expected in either growing timber, or roughly squared deal and plank. The usual practice, therefore, in measuring timber is to girt the piece, when tapering pretty regularly, in the middle of its length, with a line, and take the fourth part of this girt for the side of a square, equal to the section of the piece at that point, which multiplied into the length will give the solid contents required. Thus a squared plank 36 feet long measures round the middle 44 inches; how many solid feet of timber does it contain?

	in.	
Girt	44	
¼	11	
	11	
Sq.	121	
	432	
	242	
	363	
	484	ft.
1728)	52272	($30\frac{1}{4}$
	5184	

Here the 4th part of the girt 11 inches is taken for the side of a square containing 121 inches, which multiplied by 432, the inches in the length 36 feet, will give for a product 52272 solid inches. This divided by 1728, the solid inches in a foot, will quote $30\frac{1}{4}$ feet for the solid contents of the plank.

```
        ..432
            4
        -----
1728) 1728 (1
      1728
      ----
      ....
```

This method is however by no means correct, as will appear by the following statements. The plank now described as measuring 44 inches in girt, or 11 inches a side in the middle, is supposed to be 14 inches a side at the great end, and 8 inches a side at the small end.

```
             in.                in.
Great end  14      Little end  8      Area of Gt. end  196
           14                  8
           ---                 --
Area      196      Area       64      ----  Lit. —     64
           64                         ----  Mid. —    112
          ----                                       ----
          784                               Sum       372
        1176                          ⅓ of length     144
        ------                                       ----
        12544 (112 area of middle.                   1488
        1 . .                                       1488
        -                                           372
   21) .25                                          ------  ft.
        21                               1728) 53568 (31
        -                                      5184
  222) 444                                     ----
       444                                     .1728
       ---                                      1728
       ...                                      ----
                                                ....
```

It is however in the measurement of round timber that the error of the common method is the most important: as in this example. The length of a new-felled tree is 24 feet, and the girt round the middle of its length is 120 inches; required the number of solid feet in it.

```
      Common method                       True method
Girt at middle  120              3.14159) 120,0000 (38.2
                ---                       942477
¼                30                       -------
                 30                       2575230
                ---                       2513272
                900                       -------
Length inches   288                        ..619580
                ---
```

1728) 259200 (150 ft.
1728
————
8640
8640
————
....0

$\frac{1}{2}$ Circumf. 60 inches
$\frac{1}{2}$ Diam. 19.1 inches
————
1146.0
Length 288
————
9168
9168
2292
————
1728) 330048 (191 ft.
1728
————
15724
15552
————
..1728
1728
————
....

The common or customary method takes $\frac{1}{4}$ of the middle girt for the side of a square, of which the area, as above, is 900 square inches; and this multiplied by the inches of length 288, gives 150 solid feet for the contents of the tree. On the other hand, taking the girt in the middle as the circumference of a circle, in the true method, we find the diameter to be 38.2 inches, and the area of this circle to be 1146 square inches, instead of 900 found in the customary way, which multiplied by the length, gives for the solid contents of the tree 191 feet, instead of 150 feet before found. Thus it will always be found that, in measuring round or growing timber, the customary method will give a result about one-fourth less than the truth. In four-sided logs of timber the more unequal that are the sides, and the more the corners depart from right-angles, the more will the solid contents, found in the common way, come short of the truth. The pretence for using the customary method is however that, by it an allowance is made for the bark and other parts to be taken off, in squaring growing or new-felled timber. But, independently of this, it is usual to allow one-tenth or one-twelfth for bark upon oak timber; but less upon other kinds of trees.

CHAP. X.

GAUGING.

BY this branch of measurement we discover the contents of any vessel, such as a barrel, a cask, a copper, a vat, or the like. Were barrels and casks constructed on such principles that, in their form they resembled any regular figures, their contents might be ascertained with equal facility and accuracy. This, however, not being in general the case, various methods have been devised for shortening the labour that would be necessary for correctly determining their contents, and of coming sufficiently near the truth, for the ordinary occasions of life.

A cylindrical vessel, that is, round at each end, and of equal diameter all through its length, having an even bottom, being *seven* English inches diameter in all parts, and *six* inches deep, from the top of the inside to the bottom, (which vessel will be found by calculation, to contain 230.907 cubical or solid inches,) or any other vessel of the same capacity, or for the sake of round numbers, containing 231 cubical inches, and no more, is deemed to be a lawful English *wine* gallon. An English *wine* pint, or $\frac{1}{8}$ of a gallon, must therefore be very nearly $28\frac{7}{8}$ cubic inches. Although the standard wine gallon be now fixed at 231 cubic inches, yet the standard kept in Guild-hall, being measured before many persons of distinction, on the 25th of May, 1688, it was found to contain no more than 224 such inches only. The English *beer* gallon contains 282 cubic inches; consequently $35\frac{1}{4}$ cubic inches make a *beer* pint, 2 pints a quart, 4 quarts a gallon, 9 gallons a firkin, and 4 firkins or 36 gallons, a barrel. In *ale*, 8 gallons make a firkin, and 4 firkins or 32 gallons, make a barrel: but by an act of parliament of the 1st year of William and Mary, 34 gallons are allowed to the barrel of both beer and ale, in all places excepting within the weekly bills of mortality, that is within 10 miles of the Royal Exchange of London.

In Scotland 4 jills make a muchkin, 2 muchkins a chopin, 2 chopins a pint, 2 pints a quart, and 8 pints or 4 quarts, a gallon.

These measures had originally a near resemblance to the French, and, before the union with England in 1706, were used for all sorts of liquors. The Scotch *pint* is commonly said to contain 109 cubic inches; but the standards kept in Edinburgh, one of which as old as the year 1555, having been carefully measured at different times, they gave for the Scotch pint only about 103.4 cubic inches. But the standards used by the pewterers, in making measures, contain between 105 and 106 cubic inches. A cask measured at Edinburgh, before the commissioners of excise, when first introduced into Scotland after the union with England, was found to contain 46⅞ Scotch pints, and also $18\frac{1}{10}$ English gallons. If this comparison was accurate, the Scotch pint would be to the English gallon in the proportion of 1875 to 724; and, if the English gallon contained 282 cubic inches, the Scotch pint would contain 108.89 inches. The Winchester *corn* gallon contains 272¼ cubic inches.

A tub or vat with straight sides, but wider at the top than at the bottom, is a *frustum* or portion of a cone, and its contents may be found, as was shown when speaking of that figure (Art. 5. Mens. of Solids:) and if two such tubs or vats were placed with the mouths against each other, they would bear some resemblance to a barrel. But the sides of a barrel are, in no part, straight lines; being bent outwards all the way from end to end. The difficulty of gauging casks is chiefly occasioned by the variety of the curves of their sides: those that are the most bent resembling the middle portion of a spheroid, while those that, on the same diameters at the ends and bung, are formed with straight sides may be considered, as before said, to be portions of cones joined together at their greater bases. Between these extremes other varieties are found, but commonly reduced to two. In the practice of gauging casks, the officers of the excise are obliged to follow one general rule, in which they suppose a cask to be of the same dimensions in head, bung, and length, and yet by reason of the greater or less archedness of the staves, the contents may be very different. This is the method laid down in Everard's system of gauging; and agreeably thereto, are the several varieties marked upon the gauging sliding-rule, in order to reduce each variety to a mean diameter, or to that of a cylinder of contents equal to the cask. The casks being reduced to four varieties of curvature, multiply the difference between the head and bung diameters, provided it be less than 6 inches, in the following way; viz. by .68 for the greatest curvature or the 1st variety; by .62 for the 2nd variety; by .55 for the 3rd; and by .5 for the 4th, when the sides of the cask are straight from the ends to the bung. But if the difference between the head and bung diameters be more than 6 inches, it must be multiplied by .7 for the 1st variety; by .64 for the 2nd; by .57 for the 3rd; and by .52 for the 4th. If to these several products be added the head diameter, the sum will be the mean diameter of each variety of cask.

The contents of the cask are found in this way. Square the mean diameter, and multiply the square by the length of the cask; again multiply (or divide) this last product by the factors (or divisors)

given in the following table, and the product (or quotient) will be the contents of the cask. Or the rules given in *Mensuration*, find the circular area or the mean diameter, as that of a cylinder equal to the cask, and this multipled by the length will give the contents.

Table of Multipliers and Divisors for Circles.

	Multipliers	Divisors
Inches the area of unity	.785398	1.27324
A superficial foot	.005454	183.34
A solid foot	.000454	2200.16
Ale gallon	.002785	359.05
Wine gallon	.003399	294.12
Malt or Corn bushel	.000365	2738.00
Malt gallon	.002922	342.24
Mash-tun gallon	.003460	289.00

1. Example. Let it be required to discover the contents of a cask of which the diameter of both heads is 23 inches, that of the bung is 26.5 inches, and the length is 28.3 inches, and the staves are of the greatest curvature, that is of the 1st variety.

Bung Diam.	26.5	Mean D.	25.4
Head D.	23.0		25.4
Diff. of D.	3.5		10 16
Multiplier	.68		127 0
			508
	280		
	2 10	Square	645.16
	2.380		
Head D.	23.		
Mean D.	25.38 or 25.4		
		Square	645.16
		Length	28.3
			193 548
			5161 28
			12903 2
			18258.028

Now, this last product multiplied by .002785, or divided by 359.05 the numbers in the table corresponding to ale gallons, will give the same result for the contents of the cask.

18258.028	Ale G.
.002 785	359.05)18258.028)50.8509
91290140	17952 5
1 46064224	305528
12 7806196	287240
36 516056	182880
Ale G. 50.848607980	179525
	335500
	323145
	12355

The difference between the results is only about three quarters of an inch, which in such an operation may safely be neglected. If the contents of the other varieties of curvature be computed the whole will be as follow.

1st variety, or	spheroid	50.85	Ale gallons.
2nd	parabolic spindle	50.05	
3rd	parabolic conoids	48.87	
4th	double conic frustum	48.28	

2. Example, in which the difference between the head and bung diameters is more than 6 inches. Let the length of the cask be 42 inches, the head diameters 24.5 inches, and that at the bung 31.5 inches: required the contents of the four varieties of casks, all of these dimensions, in ale gallons?

Bung D.	31.5
Head D.	24.5
Diff.	7.

To Head Diam. 24.5 add	7×.7 =29.4	Mean Diams.
	7×.64=28.98	
	7×.57=28.49	
	7×.52=28.14	

Areas of these mean Diams.	2.407	which multiplied by length 42.	101.09	Ale Gals.
	2.339		98.23	
	2.261		94.96	
	2.2..		92.65	

But the contents of all varieties of casks may be found in a different way, in the following manner. For the spheroid or 1st variety. To twice the square of the bung diameter add the square of the head diameter; multiply this sum by the length of the cask, and divide the product by 1077.15 (or merely by 1077 neglecting

the fraction) which is 3 times the circular divisor 359.05 for ale gallons given in the table; then the quotient will be the content of the cask in those gallons. Thus, for the cask, in example 2.

Bung D.	31.5			
	31.5			
	1575			
	315	Sum	2584.75	
	945	Length	42	inches
Square	992.25		5169 50	
	2		103390 0	
				Ale galls.
	1984.5	1077)	108559.50	(100.798
H. D. sq.	603.25		1077	
	2584.75		···8595	
			7539	
			10560	
			9693	
			·8670	
			8616	
			··54	

To find the wine gallons in the same cask, the divisor, instead of 1077, would be 882.36 (say 882) being 3 times the circular divisor in the table, for wine measure.

For the 2nd variety, to twice the square of the bung diameter, add the square of the head diameter, and from the sum subtract two-fifth parts of the square of the difference of these diameters; multiply the remainder by the length of the cask, and divide the product as before by 1077, when the quotient will be its contents, which in this case will be 100. ale gallons.

For the 3rd variety, multiply the sum of the squares of the head and bung diameters by the length of the cask, and divide the product by twice the circular divisor given in the preceding table; when the quotient will be the contents of the cask in the same denomination with the divisor employed, as in this case 93.2 ale gallons.

For the 4th variety, from the sum and half-sum of the squares of the head and bung diameters, subtract half the square of the difference of these diameters; then multiply the remainder by the length of the cask, and divide the product by 3 times the circular divisor in the table; when the quotient will be the content of the cask, in the denomination of that divisor. In this instance the content is 92.2 ale gallons.

In comparing the results of these methods of gauging casks with

the former, the contents come sufficiently near to each other, for common purposes: nor is it possible to say which of the two is the best, on account of the irregularity of the shape of casks, even when made with the greatest care.

Casks may also be measured without regarding the variety of curvature of the staves, by means of a fourth dimension, which is the diameter in the middle between the bung and the head of the cask. In order to discover this 3rd diameter the following directions are to be followed.—Get a ring just to fit the gauging rod, so as to slide up and down as wanted. In the inside of the ring file a small notch, in which a fine line may move freely, by the weight of a plummet at the end. Pass the rod thus prepared through the bung-hole, inclining it so as just to touch the lowest point of one of the heads, where the staves end, and observe the length within the cask. Then taking out the rod fix the ring at the middle of that length, and returning the rod into its former place, let the line slip down until the plummet rest on the staves in the lower side of the cask. Keeping the line fast upon the rod, draw both out of the cask, and measure the length from the ring to the end of the plummet. Now from half the bung diameter subtract one-fourth part of the difference between the head and bung diameters. Again, subtract this remainder from the distance in inches found from the ring to the bottom of the plummet; and, doubling this last remainder, add it to the head diameter, when the sum will be the required diameter in the middle, between the head and bung.

Suppose as before the length of a cask to be 42 inches, the bung diameter 31.5 inches, and the head diameter 24.5. In this case, if the rod be introduced at the bung, and laid inclined to the opposite end of the staves, at one of the heads, the length of rod within the cask will be 35 inches, and the length of the line and plummet, suspended from the ring at the middle of the rod, is by supposition 16.5 inches. Now we proceed thus,

Bung D.	31.5
Head D.	24.5
Diff.	7
½ Diff.	3.5

½ Bung D.	=	15.75
¼ Diff. of D.	=	1.75
1st Rem.	=	14.
Line and Plum.	=	16.5
2nd Rem.	=	2.5
		2.5
Double do.	=	5.
Head D.	=	24.5
Middle D.	=	29.5

Having thus found the diameter of the cask, the content is found by the following rule.

To the square of twice the middle diameter, add the squares of the head and bung diameters; multiply their sum by one-sixth part of the length, and the product multiplied by the circular factors in the table will give the content in gallons.

Middle D.	29.5		35514.5
	2		.00278 5
	59		177572 5
	59		2841160
			2486015
Sq.	3481.		710290
B. D.	992.25		
H. D.	600.25		98.907882 5 ale gallons.
	5073.5		
$\frac{1}{6}$ length	7		
	35514.5		

Ullaging is ascertaining the void space in a cask, only in part filled with liquor; or how much liquor it contains; and is so named from the Latin *ullus*, signifying any or what quantity.

When a cask lies on its side, and the depth of the liquor is measured by the rod standing perpendicularly, the rule is to divide the wet inches by the bung diameter, and if the quotient be under .5, *subtract* from the quotient $\frac{1}{4}$ part of what that quotient wants of .5: then multiplying the remainder by the total content of the cask, the product will be the quantity of liquor in the lying cask. For instance, if a cask containing when full 56 gallons, the bung diameter is 28 inches, but the depth of liquor measured from the bung is only 12 inches. Required the quantity of liquor in the cask, lying on its side and horizontal.

	Wet in.	.500	
B. D. = 28)	12.000	(.428	= quotient
	11 2		
		.072	= difference
	80		
	56	.018	= $\frac{1}{4}$ difference
	240	.410	
	224	56	= content of cask
	16	2 460	
		20 50	
		22.960	= gallons in cask
		56.	
		33.04.	= void space.

When the quotient of the wet inches divided by the bung diameter is above .5, then *add* $\frac{1}{4}$ part of the excess to the quotient, and the sum multiplied by the content of the cask will give the quantity of liquor in the cask.

To find the content of the ullage of a cask standing upright on the head; divide the wet inches by the given length of the cask, and if the quotient be under .5, *subtract* from the quotient $\frac{1}{10}$ part of what the quotient wants of .500. But if the quotient exceed .5, to it *add* $\frac{1}{10}$ of the excess. Then if the remainder in the first case, or the sum in the second, be multiplied by the content of the cask, the product will be the quantity of liquor in it. Let as before the full content of a cask be 56 gallons, and its length be 34 inches, and the depth of liquor in it, when standing upright on the head, be 12 inches.

Wet in.	.500
L. 34) 12.000 (.34	.353
10 2	———
———	.147
1 80	———
1 70	.0147 = $\frac{1}{10}$ difference
———	———
100	.3383
102	56 content of cask
———	———
	2 0298
	16 915
	———
	18.9448 gallons in cask.

In no part of practical measurement are the opinions of writers more at variance, than in the gauging of casks: the four varieties before mentioned are however sufficient for every useful purpose: at the same time, that no cask was perhaps ever made, that corresponded with either of them. The following rule is nevertheless recommended by Professor Hutton of Woolwich, in his Mathematical Dictionary, as having been confirmed by an appeal to the actual measurement of the cask, by observing how many gallons, &c. it really contained. This rule is to add together 39 times the square of the bung diameter, 25 times the square of the head diameter, 26 times the product of these diameters: multiply the sum by the length of the cask, and the product by the number .00034; then this last product divided by 9, will give the *wine* gallons, and divided by 11, the *ale* gallons.

The open vessels employed by brewers, distillers, &c. such as mash-tuns, backs or coolers, coppers, &c. are commonly of regular forms, although wider at top than at bottom. In computing their contents therefore, the rules are to be followed already given for measuring solid bodies. Thus, if a circular vessel be 56 inches in diameter at bottom, and 72 inches at top, the depth being 45 inches; by adding the two diameters together, and taking half

the sum, by 64 inches, we obtain the diameter of a cylinder equal in content to the vessel. The superficial area of a circle of 64 inches diameter, multiplied by 45 inches the depth, the product divided by 282 will give the ale gallons, by 231 the wine gallons, &c.

Farther to enter on the practice of gauging would be equally foreign to the purpose, as to the limits of the work. It will therefore be sufficient to have shown the principles on which this apparently mysterious branch of measurement is founded. In practice, by means of the gauging rod and sliding-rules, with the aid of tables accurately calculated, the several operations of gauging are greatly abridged, and with sufficient precision for ordinary business. The treatise on this subject now in universal request is, *The Practical Gauger by William Symons, Collector of Excise*, a work in octavo, published under the sanction of the Board of Excise in London.

Under gauging may be included the method of measuring the burden of a ship, or how many tons weight she will carry. The rule here is to multiply the length of the keel, taken within board, by the breadth of the ship within board, taken on the midship beam, from plank to plank, and this product by the depth of the hold, taken from the under part of the upper-deck plank, to the plank below the keelson. This last product divided by 94, will give the tonnage required.

Another rule is to state this proportion; As 1 to the breadth of the ship, so is half that breadth to a fourth number. Again say, As 94 to this 4th number, so is the length of a ship to her tonnage. For instance, if a ship be 75 feet by the keel, and 23 feet by the beam, what will be her tonnage?

```
        B.   ½ B.          4th N.    L.
As 1 : 23 :: 11.5 : —As 94 : 264.5 :: 75 :
       11.5                   75
       ————                  ——————
       34 5                  1322 5
      230                   18515
      —————                 ——————— Tons.
4th No.=264.5           94) 19837.5 (211
                            188
                            ———
                             103
                              94
                             ———
                              97
                              94
                              ——
                               3
```

Now in this method no consideration being had of the depth of the ship; but all ships being supposed to be built on precisely the same proportions, which is notoriously not the case; we need

not wonder if, abstracting from every other variety of shape, the tonnage turn out the same in vessels of very different capacity and burden, and turn out different in vessels of the same capacity.

Thus, suppose the same ship to be in depth 13 feet, and she be measured by the first rule, her burden will be 238½ tons, instead of 211: Thus,

```
    Length  75 feet
    Breadth 23
            --
           225
          150
          ----
          1725
Depth       13
         -----   Tons
     94) 22425 (238.5
         188
         ---
         .362
          282
          ---
          .805
           752
           ---
           .530
            470
            ---
            .60
```

This is the nearest to the real capacity of the ship: but the other is the result of what is called carpenter's measure; which is always supposed to give a tonnage considerably less than the true burden of the vessel.

CHAP. XI.

SURVEYING OR LAND-MEASURING.

BY *surveying*, is understood the art of measuring the superficial contents of a field, an estate, a parish, a county, &c. comprehending in its full extent three several operations, viz. 1st, Making the survey, or measuring the dimensions of the ground. 2nd. Delineating or laying down upon paper a correct representation of the ground surveyed: every part and object being shown in its due situation and proportion with respect to others. And 3rdly, Calculating or casting up the area or superficial contents of the several portions and of the whole. The first operation of surveying consists of two parts, the measurement of the angles, and that of the sides of the ground surveyed: the former is principally performed by the *theodolite*, and the latter by the *chain*, by which also angles may be very correctly ascertained. The quantities of the angles and the lengths of the sides and other dimensions of the ground are regularly entered, together with all other necessary particulars, in the *Field-book;* at the same time that a general draught of the whole is, by some surveyors, made out upon paper, by means of the instrument called the *Plain Table*.

The *theodolite* is a circle of brass of 6, 9, or 12 inches diameter, strengthened by two cross bars intersecting at right-angles in the centre. The circular part, or *limbe* as it is called, is divided into 360 degrees, minutes, &c. To the circle is adapted a small telescope for the more accurately viewing objects at a distance; and on the centre of the instrument moves a circular plate or index, having in the middle a mariner's compass, to point out the situation and bearings of objects, with another small telescope. At each end of these telescopes are plain sights for observing objects near the eye. The instrument is also furnished with spirit or other levels, for placing it truly horizontal. The whole is mounted on a fulcrum or three-legged staff, with a ball and socket, and other con-

trivances, for placing the theodolite in any required position. The *graphometer* is one-half of the theodolite, containing only a semicircle or 180 degrees: it wants also the telescopes: but its uses are the same with those of the circular instrument. In using either of these instruments, it is placed by means of a plummet hanging from the centre, exactly over the angular point, or as near to it as may be possible. Suppose this to be the corner of an inclosure bounded by hedges. Looking through the telescope or sights fixed on that diameter of the circle, where the degrees begin to be counted from 0, direct that diameter along the line of one of the hedges and screw it fast: then move the moveable arm or index with its sights round, until it stand exactly along the line of the other hedge, forming the angle where the intrument stands, and screw it fast. Next looking on the limbe of the circle, observe how many degrees, minutes, &c. are intercepted between the index and the beginning of the scale, which will point out the quantity of the angle measured.

The *plain-table* is an instrument by which a plot or draught of a piece of ground may be drawn with sufficient accuracy, as the survey goes on in the field. It consists of a plain rectangular or square board, fixed on a fulcrum or tripod, but moveable in all directions. To it is adapted a frame sitting close round the edges, to fasten the paper on which the draught is to be made. On the sides are marked scales of equal parts for measuring off distances, and of degrees, &c. that the instrument may be used as a theodolite; it has also a compass and a moveable index with sights, to take angles and bearings.

The instruments commonly used for measuring lines are the *chain* for shorter, and the *perambulator* for greater distances. The English chain consists of 100 links, each link being in length 7.92 inches, consequently the whole chain contains 792 inches, or 66 feet, or 22 yards, or 4 poles. This is commonly called *Gunter's* chain, from the inventor, an ingenious practical geometrician who died about the year 1626; and it is peculiarly adapted to the measurement of land, because 10 square chains are precisely an English acre: so that the dimensions of a field being taken in these chains, and the area or contents computed in square chains, the tenth part of the product will be the number of acres required.

Scotch acres, &c. being greater than the corresponding measures in England, the Scotch chain is proportionably longer than the English: for although it be likewise divided into a 100 links, yet the whole length of the chain being, not 22 yards, but 24 Scotch ells, equal to 74 English feet (or rather to 74 feet 4½ inches, on account of the excess of the Scotch above the English foot) the links of the Scotch chain contain 8.928 English inches; consequently 4 Scotch acres are something more than 5 English acres.

In measuring with the chain the surveyor provides ten small rods of iron or wood called *arrows*, to be carried by the leader or person who draws the chain, and one is to be struck in the ground at the end of each chain, to be gathered up by the follower as he comes

up. By these arrows the follower reckons the number of chains run over in any one course. For readiness in counting the links the chain is divided into tens, by pieces of brass marked both ways from the handles at each end to the 50th link in the middle, which is usually a circular plain piece of brass. In using the chain, the follower (commonly the surveyor himself) holds the end of the chain at the spot where the measurement is to commence, while the leader walks on, drawing the chain by the other end after him until it be stretched to its full length. Then looking back, he moves to the right or left as directed by the follower until the end of the chain in his hand be precisely in a line with the object upon which the distance is to be measured. In this situation the leader sticks an arrow in the ground exactly at the end of the chain, and then goes on drawing it after him in the same direction, until the follower come up to the arrow. Here when in the true line of direction the leader sticks another in the ground; and in this way proceeds to the end of the course. The number of arrows taken up by the follower shows how many complete chains are in the line measured, which, with the number of odd links, if any, between the last placed arrow and the end of the line, will give the whole distance between the two extremities. Thus if the follower hold 6 arrows and that the distance beyond the last arrow and the end of the course be 75 links, he knows the whole line measured to contain 6 chains and 75 links, written down thus 6ch. 75l. or 6.75ch. or 675 links.

It was already said that not only lines and sides of fields &c. but also angles may be accurately measured by the chain. This practice depends on the property of all right-angled triangles, (see the beginning of Mensuration of Surfaces) that the square constructed on the hypothenuse or side opposite to the right-angle, is always equal to the sum of the two squares, constructed on the two sides, forming the right-angle, or the base and the perpendicular. The numbers 3, 4, and 5, are just such that if a triangle were formed with sides of these lengths, it would be right-angled at the meeting of the sides 3 and 4, and opposite to the side 5. But not these precise numbers alone will form a right-angled triangle; any repetitions of them will do the same thing. Thus if we take 6 times each, or 18, 24, and 30: the square of 18 is 324, and the square 24 is 576; their sum is 900, the square root of which is 30. Hence if we construct a triangle the sides of which shall be 18, 24, and 30 links, feet, yards, &c. it will be right-angled at the meeting of the two shorter sides. Let the 100 links in a chain be divided by the sum of 3 + 4 + 5 or 12, the nearest quotient is 8. Multiplying therefore these numbers by 8 we have 24, 32, and 40, in all 96, as the number of links out of one chain with which a right-angled triangle may be constructed in the field. To do this fix an arrow in the ground at the point where the right-angle is to be formed: over this arrow lay the ring connecting the 24th and 25th links together; carry the beginning of the chain along the line to be the base of the triangle, and fix it with another arrow, which will be distant 24 links from the first; then counting 32 links from

the 24th that is the 56th, and 40 links more that is the 96th, place this last over the arrow at the beginning of the chain, when a third arrow placed at the end of the 56th link, in the double of the chain, will point out a spot exactly perpendicular to the angular point occupied by the arrow first placed, in the 24th link. In this manner a right-angle may be formed, or a perpendicular may be raised, at any given point by the chain. But to measure an angle on the ground, formed by two hedges, walls, or other bounding lines, the process is still more simple. Measure to any convenient distance along both lines, the longer the better, and then measure the distance across the field between the extremities of those two measured spaces: by this operation the ground, a farm, for instance, may be planned and cast up with much more accuracy than can possibly be done by the use of any circular instrument for measuring angles whatever. A perpendicular may also be let fall from any given point upon a line, by the chain with great expedition. Placing one end of the chain at the given point (distant not more than 85 links or so from the line) with the other stretched out just to touch the given line, make marks on each side of the spot where the perpendicular must fall: the point exactly in the middle between these two marks will be that to which a perpendicular from the original point will be directed.

The operations, the reader will perceive, are only doing with a chain or other measuring line in the field, what he does with compasses on paper in the house.

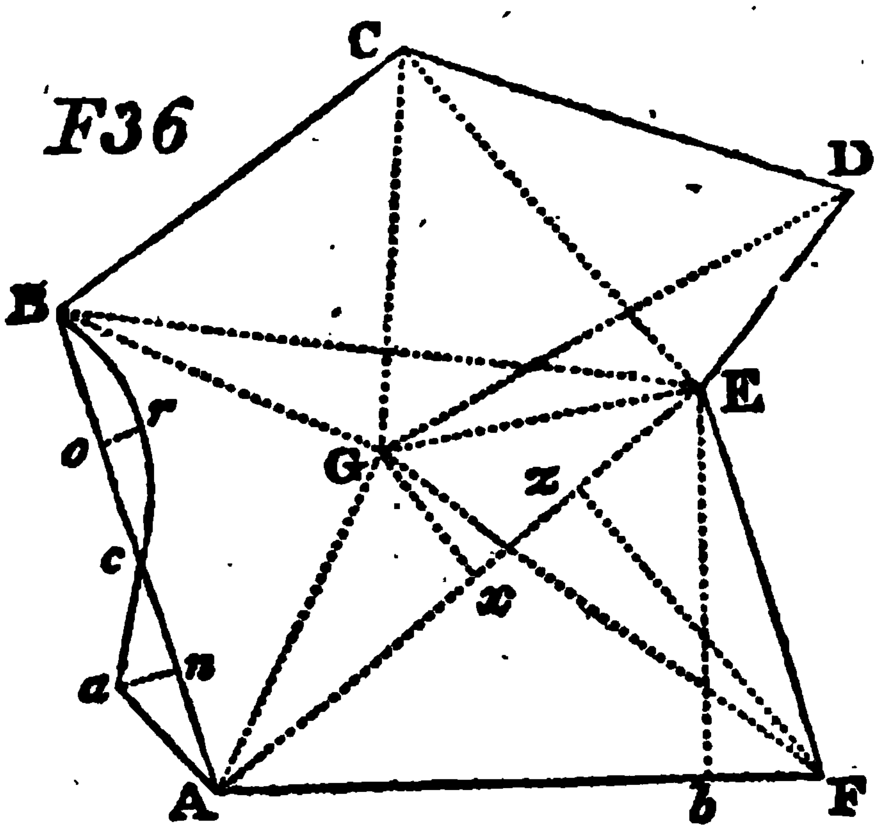
Another instrument for measuring distances is the *perambulator*, so called because it works by the revolution of a wheel, or the *odometer*, a name signifying merely a machine for measuring the way or road: of these last some are applied to the wheel of a travelling carriage, and others can be carried in the side-pocket, to count the revolutions of the wheel, or the steps of the bearer, and thence to ascertain the road-distance travelled over. None of these machines however are fit for surveying land, because by sinking into every hollow, and mounting over every height, they constantly give the distances greater than the truth.

2. The second operation of the surveyor is to lay down upon paper, vellum, &c. a correct and faithful delineation or plan of the land surveyed, exhibiting the boundaries, internal divisions of farms, inclosures, woods, and plantations, meadows, commons, hills, rivers, ponds, buildings, gardens, and all other objects necessary for conveying a just notion of the estate, county, &c. The lines of distance are laid down from scales of equal parts, usually representing chains and links, because of their relation to the common denominations of land-measuring. The angles are laid down by the compasses from a scale of chords (Geom. Circle) or by means of the *protractor*, an instrument containing a semicircle or 180 degrees. In laying down an angle, the straight side is accurately applied to the given line, with the central point at its extremity, the degrees are then counted off on the semicircle, by which is fixed a point through which a line drawn from the extremity of the first will form the angle required. If however the angles

have been measured with the chain they must be laid down on paper from a scale of equal parts, corresponding to chains and links.

3. The third and most important part of the surveyor's duty is to calculate or cast up the area or superficial content of the several inclosures, fields, or other divisions of the land surveyed. In speaking of mensuration of surfaces, it was observed, that all plane figures however irregular, may be divided into triangles, by lines crossing them from angle to angle, or from each angle to a point chosen towards the centre of the ground. Let the annexed diagram, fig. 36, represent a piece of land, of which the boundaries are the curved line A *a c r* B, and the straight lines B C, D E, F A. But for the present let us pass over the bendings between A and B, and that the boundary in that part is the direct line A B. If from any corner of the ground, the most convenient, as at E, lines be drawn to the opposite corners, as E C, E B, E A, the ground will be thrown into the 4 triangles E D C, E C B, E B A, and E A F: for lines drawn from an angle will always divide any figure into as many triangles as it has sides, except two, and fig. 36 is six-sided. Knowing the external sides of the figure, and the length of the lines drawn from E, the contents of these 4 triangles may be calculated, and their sum will be the area of the ground.

F36



Again, from some central position as at G, let lines be drawn to each angle as G A, G B, G C, G D, G E, and G F, forming just as many triangles as the figure has sides. If these lines from G be measured, all the sides of the 6 triangles are given, and their several areas may be computed for the total contents of the ground. These several dimensions are:

Boundaries.	Ch. L.	Lines from E.	Ch. L.	Lines from G.	Ch. L.
A B	10.48	E A	12.88	G A	7.68
B C	9.12	E B	13.60	G B	7.28
C D	10.00	E C	9.36	G C	8.32
D E	5.28			G D	11.20
E F	8.32			G E	6.80
F A	12.64			G F	11.36

By employing the lines drawn to the opposite angles of the

figure, we can compute the content of the whole survey, without regard to its subdivision into separate fields by the straight fences meeting at G, viz. G A, G C, and G E, forming with the outward fences the 3 four-sided inclosures A G E F, A G C B, and C G E D, which can be computed only by the lines drawn from G.

1. For the content of the whole survey let us begin by the triangle A E F, of which all the sides are known. To find the perpendicular E *s*, agreeably to the rules formerly given, we have this proportion.

As Base to Sum of sides, so Diff. of sides to Diff. of Segments.

A F	:	A E+E F	::	A E−E F	:	A *s*−*s* F
12.64	:	12.88+8.32	::	12.88−8.32	:	
		8.32		8.32		
		21.20		4.56		
		4.56				

```
        1 2720
        10 600
        84 80                        12.64
        ------                       -----
12.64)  90.6720 (7.64          ½ Base  = 6.32
        88 448   3.82        + ½ Diff. = 3.82
        ------                         -----
         8 192                  A s    =10.14
         7 584
        ------
          6080                 ½ Base  = 6.32
          5056               − ½ Diff. = 3.82
          ----                         -----
          1024                  s F    = 2.50
```

Now, in the right-angled triangle A *s* E, if from the square of A E = 12.88 = 165.8944, we subtract the square of A *s* = 10.14 = 102.8196, and of the remainder = 63.0748 extract the square root, we obtain 7.94 for the perpendicular E *s*, which multiplied by one-half of the base A F, or 6.32, will give 50.1808 square chains, to be brought into proper land-measures as in the margin. The square chains divided by 10 give acres; and the remainder successively multiplied by the roods in an acre, the square poles in a rood, and the square yards in a pole, will give 5 acres, 0 roods,

```
      Sq. Chains
   10) 50.1808 (
       --------
   A.   5.01808
              4
        -------
   R.   0.07232
             40
        -------
```

2 poles, and 27 yards, for the superficial area of the triangle A E F.

P. 2.89 280
30.25

446 40
1785 6
26 7840

Y. 27.0072

If in the same we calculate the length of perpendiculars let fall from B upon A E, from C upon B E, and from D upon C E, we can compute the areas of the other triangles A B E, B C E, and C D E; which, with that of A E F, will be the whole content of the land surveyed.

On the other hand, considering the same extent of land as distributed into three quadrangular fields, A G E F, A G C B, and C G E D, if to the triangle A E F, already cast up, we add the triangle A G E, the sum will be the content of the field A G E F. Let this operation be performed.

A E : A G+G E :: A G−G E : A x−x E
12.88 : 7.68+6.80 :: 7.68−6.80 :

```
         6.80       6.80
        ------     ------
        14.48        .88
          .88
        ------              A E = 12.88
        1 1584                   -------
       11 584                      6.44
       -------                  +  .49465
12.88) 12.7424 (.9892            --------
       11592    .49465      A x = 6.93465
       -----                     --------
        11504              ½ A E = 6.44
        10304                   −  49465
        -----                    --------
         12000              x E  = 5.94535
         11592                   --------
         -----
          ..4080
           3864
           ----
            216
  A G=7.68                  A x = 6.93465
      7.68                        6.93465
      ----                        -------
      6144                        3467325
     4 608                       4160790
    53 76                       2773860
    -------                    2080395
    58.9824                   6 241185
                             41 60790
                             -------------
                             48.0893703225
```

```
                                                   Sq. Chains
   58.9824                                     10) 20.2520
   48.0893706225                                   -------
   -------------                                A.  2.0252
   10.8930293775 (3.30 = G e                            4
    9 . . . . . .  1.65                             -----
   --               12.88 = A E                 R.  0.1008
63)189              -----                              40
   189               6440                           -----
   ---              7 728                       P. 4.03 20
   ...30           12 88                           30.25
                   ------                          -----
         Sq. Ch.  20.2520                           1600
                  -------                            640
                                                   9600
                                                   -----
                                                Y. 0.968...
                                                   -----
```

	A	R	P	Y
The triangle A G E contains therefore	2..	0..	4..	0.968
And A E F, before computed	5..	0..	2..	27.0072
Area of the field A G E F, Acres	7..	0..	6.	27.9752

In the same way are the other two fields cast up; and the amount of the three taken together will be equal to that found by means of the 4 triangles before computed. By thus taking different dimensions of ground, and by thence computing its area, distributed into figures of different shapes, we have at once the most severe but the most accurate mode of discovering its real content. It is however to be observed that the same piece of land, measured not only by different dimensions, but even on the same lines, by the most skilful and attentive surveyor and assistants, and with the best constituted instruments, will never furnish precisely the same measures, and consequently the computations founded on them can never absolutely coincide.

In the foregoing operations we have proceeded on the supposition that the boundary from A to B is one continued straight line. This however is not the case, for from A the fence runs outwardly, but straight, to *a*, where it forms an angle towards the ground surveyed, and runs on straight to *c*, where it meets the measured, but imaginary line joining A to B. The figure A *a c* is therefore a right-lined triangle, of which the three sides may be measured in the field, and its content cast up, as before shown. Where the boundary or fence, however, deviates but a small quantity, as in this case, from the measured line A B, it is considered to be sufficient in practice to measure the distance between the extremities of the deviation, as here the length of A c, and the length of a perpendicular *a n* from the vertex of the triangle to the base. The length of A *c* is 1 chain 34 links (1.34) and the

perpendicular $a\,n$ is 28 links, (.28,) half of which .14 multiplied by the base A c 1.30 gives .1820 of a square chain, equal to 2 poles 27.588 yards. But this quantity lying on the outside of the measured line A B, it is to be added to the content of the field A G C B. Again, at the point c, the bounding fence crosses the measured line A B, and sweeps round in a curve to B. The portion of land A a c consisting of straight lines, it was measured as a triangle; but the portion c r B is formed by a curve partaking of a circle: it might therefore be computed according to the rule formerly given for measuring the segment of a circle. But as a curve of such geometrical accuracy cannot be expected in a fence following the windings of a road or a river, it is customary to measure such irregular deviations from a right line by taking a number of perpendiculars from the fence to the base, like r o in the figure, by a medium of which the content may be found. The most correct way is to multiply half the sum of two adjacent perpendiculars by the intermediate distance between them, for the area of the space included by them; and the sum of all these products is the area of the figure. In common practise however, the area of such a curved space as B o c r is found by taking several breadths as o r, adding them all together, and dividing the sum by 1 more than the number of breadths. Thus between c and B are measured 5 perpendiculars, of which the longest in the middle is $o\,r = 20$ links, the others between o and c are 17 and 12, and those between o and B are 18 and 11. The sum of these breadths is 78, which, divided by the number of breadths $5+1 = 6$, will give 13 for a medium; and this multiplied by the length of the base $c\,\mathrm{B} = 1.34$, gives for the area of the figure .1742 of a square chain, equal to 2 poles 24.1128 yards. But this quantity being included within the measured line c B, it must consequently be deducted from the content of the field A G C B, when the remainder will be the true quantity of land comprehended within the right lines A G, G C, and C B, and the mixed crooked line B r c a A. The breadths or offsets of such small pieces of land as those here mentioned, are measured at right-angles to the line of measurement by the chain itself, or by a wooden rod exactly ten links in length, and hence called the offset-staff.

CHAP. XII.

NAVIGATION.

BY *Navigation*, as a branch of science and art, we learn to conduct a ship from one port to another, across the ocean, and to ascertain her position, at any intermediate point of her voyage. In navigation two things are supposed to be known; the direction or the *course* on which the ship sails, and the space or *distance* sailed on that course. The course is ascertained by the means of an instrument called the *mariner's compass*. The value of this instrument, admirable as it is simple, arises from the property peculiar to the *magnet*, that, when at liberty to move freely, it invariably stands with the one part towards the north and the other towards the south. The magnet possesses a particular affinity with iron, which it attracts in preference to every other substance. To iron it also communicates its own distinguishing properties, of attracting other iron, and of placing itself in the direction of the axis or poles of the earth. The magnet is indeed itself an ore of iron, of a dark brown or nearly black colour. It is found in many places; but in antient times was chiefly drawn from the vicinity of *Magnesia* a city in *Asia Minor;* and from that circumstance it received its name among the Greeks, who first made it known to Europe. The illustrious Greek philosopher Plato, who died about 350 years before the birth of our Saviour, in a part of his writings compares the effect produced by poetry, on minds endowed with a feeling of its beauties, to the operation of the magnet on rings of iron, which it not only attracted, but empowered to act upon other rings of iron, in the same way with the magnet itself, so as to form a connected chain of magnetised rings. Had the antients, instead of making experiments with circular rings, upon any occasion employed long narrow bars of iron, may we not suppose that such bars, when at liberty to move freely in all directions, would have placed themselves as we now see them do, with the one end pointing to north, and the other to

south? Thus the polarity of the magnet and of magnetised iron bars or needles would have been early discovered, and probably have been applied, as is now the case, to the purposes of geography and navigation. The Chinese, it is said, were acquainted with the polarity of the magnet, and its use in navigation, three thousand years ago: but when we consider the very peculiar nature of the historical records of that singular people, and the very suspectable channels through which our knowledge of China has, until lately, been conveyed to us, we may safely suspend our belief of that assertion. This disbelief will be the more reasonable when we reflect that, even at this day, when the Chinese are acquainted with the magnetic needle, and have continued opportunities of observing the vast advantages derived from it by European mariners, resorting to their ports, the Chinese still make very little use of the compass; preferring a tedious winding course along and near the the coast, to a short and direct voyage across the sea, in which by loosing sight of the land, the compass would become their only guide.

It is generally asserted that the invention of the mariner's compass is due to *Flavio Gioia*, a native of Amalfi, on the coast of Italy, a little South from Naples; and this may have been the case: but that the polarity of the magnetic needle, and its use in navigation were known long before him, is placed beyond all doubt, by passages in the writings of *Hugh de Bercy*, otherwise called *Guiot de Provins*, and *James de Vitry*, both of France, who flourished in the close of the 12th century. The former who wrote in 1181, says: "the polar star does not move. Seamen have an art which cannot deceive, by virtue of the *manete*, an ill-favoured brownish stone, to which iron of itself adheres. They search for the right point [of the magnet,] and when they have touched a needle with it, and laid it on bit of straw, they place the straw on water in a bason, where it floats. Then the point of the needle is drawn infallibly towards the pole-star; and when the night is dark and gloomy, so that neither star nor moon is visible, the mariners set a light beside the needle, and they are sure that the [North pole] star is opposite to the point. By this is the seaman directed in his course; and this is an art which cannot deceive." This very curious passage, of great importance, although but little known, proves the polarity of the magnetic needle and its uses to have been known above a century before the time of *Gioia of Amalfi*: but it also shows the small progress made in its application by even the most expert mariners of the Mediterranean, and of the world. The common English name for the magnet is the *load-stone*, or more properly *lode-stone*, supposed to be derived from an antient Saxon term signifying to *lead or guide*: if this be true the polarity of the magnet must have been known in the north of Europe much earlier than in the south.

The natural magnet communicates its properties to pieces of iron or steel, then called artificial magnets, which may be made more powerful than the natural: and as they can be constructed of any convenient form they are now always employed. Both kinds of

magnet possess these properties; 1. they attract and are attracted by iron: 2. when placed on a fine central point or pivot, or suspended in such a way as to be able to move freely round, a magnet turns its ends towards the N. and S. poles of the world, the same end always turning to the same pole: when a magnet is moving about, to place itself N. and S. it is said to *traverse*. 3. When the N. pole of one magnet is presented to the S. pole of another, they attract each other: but if the same poles of two magnets are brought together they repel each other. 4. When a piece of steel in the northern hemisphere, is so balanced on a central point, as to lie perfectly level, if it be rendered magnetical the N. end will be depressed below the level, and the S. end will be elevated. This is called the *dip* of the needle, and was discovered by our countryman *Robert Norman*, in 1576. 5. It is the polarity of the magnet that renders it useful to navigators. When it is so supported as to be able to turn freely round, the pilot by observing its position can steer his course in any required direction. Thus if a ship sail from one port to another situated due N. the magnetical needle will point out the direction to be followed; and by reversing the course it will shew the direction from the northern to the southern port. In sailing due E. or due W. the magnetical needle will, by pointing N. and S. lie directly and at right angles across the ship and the direction of her course. With a little reflection and observation a ship may be steered in any intermediate direction. Although the magnet in general point N. and S. yet it does not do so exactly in all parts of the world. In some the direction points to the W. of N. and to the E. of S. or the contrary. The angle formed by the needle with the true meridian or N. and S. line is called the *declination*, or more commonly the *variation* of the needle or of the compass; and is styled *East* or *West* according as the N. end of the needle lies E. or W. of the true north. Another singular circumstance is that this variation is itself continually varying in the course of time. Thus in 1576 when the variation was first observed at London, the N. end of the needle pointed 11 deg. 15 min. to the eastward of the true N. that is to North by East. In the course of 80 years this deviation was observed to be regularly diminishing, so that in 1656 the position of the needle exactly coincided with the meridian. Not stopping there however, the N. point of the needle has moved progressively westward to the present time, when the variation westwardly is about 24½ degrees, the N. end of the needle pointing to the westward of N. N. W.

All circles, it was formerly said, are divided into 360 degrees: but in speaking of the positions of places or objects on the surface of the earth, a different division is adopted. When in any part of the northern hemisphere (that is all over Europe, the continent of Asia, two thirds of Africa, the whole of N. America, and the parts of S. America lying on the north of the great river of Amazons,) we turn our face to the sun at noon, he is then due S. from us, and the pole immediately behind us bears due N.: our right hand is turned to the W. and our left to the E. The horizon is therefore

divided into 4 equal parts or quadrants, each containing 90 degrees, by radii drawn from the spot when we stand to the N. E. S. and W. points. If again we divide any one of these quadrants, as for instance that formed by radii pointing N. and W. into two equal parts, we obtain a point partaking equally of these two directions, and therefore styled North-West. Taking now the middle point between N. W. and N. we obtain a direction much more N. than W. and consequently called North North-West. Lastly, by taking the middle point between N. N. W. and N. we have another, which lying a little to the Westward of North is therefore called North-by-West. By such halving of the circumference of the horizon it is divided into 32 equal portions by the points of the compass, which are named in order, beginning at N. and proceeding round by E. S. and W. as in the following table.

North-East quadrant.	South-East quadrant.	South-West quadrant.	North-West quadrant.
N by E	E by S	S by W	W by N
N N E	E S E	S S W	W N W
N E by N	S E by E	S W by S	N W by W
N E	S E	S W	N W
N E by E	S E by S	S W by W	N W by N
E N E	S S E	W S W	N N W
E by N	S by E	W by S	N by W
E.	S.	W.	N.

The points are also, for farther accuracy, subdivided into halves, quarters, and eighths. The whole circumference of the horizon of 360 degrees, being thus distributed into 32 equal parts, by the points of the compass, the space between any two points (which space is itself called a *point*) must contain 11 degrees 15 minutes. As however the bearing of one place or object from another, or the course of a ship cannot be expected to fall in, at all times, exactly with any precise point, it is usual and it is best to describe that bearing or course, by stating how many degrees and minutes it lies on the E. or W. side of the meridian or N. and S. line. Thus a W. N. W. course will form an angle of 6 points to the westward of N.; and each point being 11° 15′, 6 points will be an angle of 67° 30′, expressed thus, N. 67° 30′ W.:* and a course 1½ degree more to the westward could only be expressed thus, N. 69° W.

* It is proper to warn the reader against a serious error into which he may be led by consulting books or maps, composed by the natives of the south of Europe. The French, the Portuguese, the Spaniards, and the Italians, employ the terms *un quart*, *un quarto*, to signify not *a quarter of a point*, as we do, but *a whole point itself*. Thus in the writings of these nations N. 1-4th E. signifies N. by E. and not 1-4th point to the E. of N. as with us: S. W. 1-4th W. with them is our S. W. by W.

For measuring the distance sailed upon a course, the usual instruments are the *log* and the *half-minute glass*. The log is a triangular small piece of timber, with lead fixed on one side, so that it swims with the opposite corner upwards. To it is fastened a cord or line, from 100 to 150 fathoms long, divided into equal spaces by pieces of twine, having on them as many knots as there are spaces between each twine and the beginning of the line: hence those spaces themselves are generally called *knots*. The sand-glass is very small, containing only so much sand as will run out in half a minute, or in $\frac{1}{120}$ of an hour: the space between the knots should likewise contain 51 English feet, or $\frac{1}{120}$ of a nautical mile. But because it is always much safer to suppose the ship to have sailed more than less than the truth, the length of the knot is usually made only 48 feet. At certain times when the ship is on her course the log is thrown into the sea, and the number of knots on the line, run out in half a minute, by the progress of the ship, is taken for a rate of her motion through the water at that time. Hence we see in all accounts of battles, chases, or other sea-adventures, that a ship is said to have run so many knots, that is, so many miles in the hour. From the unsteady force and direction however of the wind acting on the ship, from the waves and currents of the sea, and from various other circumstances which can neither be governed nor even accurately known, this mode of computing a ship's rate of sailing must evidently be subject to great uncertainty: and this conjoined with the extreme difficulty of determining her course with geometrical accuracy, renders the *practice* of navigation as liable to error as the *theory* is certain and infallible. To remedy these defects recourse must be had to observation of the heavenly bodies, by which the place of a vessel on the surface of the globe may be determined with very great precision. According to the position of an observer, with respect to the equator and the pole, the altitude of the sun &c. would vary in a certain proportion. In our quarter of the globe the elevation of the N. pole being always equal to the latitude of the place of observation, by an accurate measurement of that elevation the latitude could be readily found. Again on the days of the equinoxes, viz. the 21st of March and the 23rd of September, the sun is in the equator, and his elevation above the horizon at noon is then equal to the difference between the latitude of the observer and a quadrant or 90°. By observing his altitude therefore on those days, that latitude will be found: and his apparent increase of altitude in summer, and decrease in winter being subjected to certain laws, the proper corrections contained in treatises of astronomy and navigation may easily be applied, for ascertaining the latitude of the place of observation.

Various instruments have been employed to measure the altitude of the sun, moon, stars, &c. above the horizon; but that which is now universally adopted is *Hadley's quadrant*, so named after the person who first published an account of it; although the first thought of the instrument originated with the ingenious mechanician Dr. Hook, and was afterwards completed by the incomparable Sir

Isaac Newton. A quadrant ought to be the 4th part of an entire circle, and contain an arch of 90 degrees: but by the application of the principles of optics, in the use of reflecting mirrors, Hadley's quadrant although formed with an arch of only 45 degrees, answers every purpose of one twice as large. By this construction the instrument containing only the 8th part of a circle, is in fact not a *quadrant* but an *octant*; and by this latter name it is always mentioned by foreigners writing concerning it. One of the peculiar advantages of this instrument is that, by means of the reflected image of the sun or other body observed, in the mirror, an observation can be made with perfect accuracy, on board ship, notwithstanding all the variety of motion produced by the waves and wind. In calculating the latitude of the observer a variety of circumstances are to be considered, in modifying and correcting the angle of elevation of the sun, &c. As the earth revolves round the sun, not in a circle, but in an ellipse nearly approaching to a circle, and that the sun is placed, not in the centre, but in a focus of that ellipse, it follows that the earth must in her revolution be nearer to him at one time than at another. This will be manifest from a look at the ellipse in Geometry, fig. 15 and 16. The apparent magnitude of the sun's body is sensibly greater in December and January than in June and July: in the former period it measures 32 minutes 38 seconds, but in the latter 31 minutes 34 seconds: the earth must therefore be nearer to the sun in the midst of our winter than in that of our summer. (See the account of the seasons in *Astronomy*.) In measuring the sun's altitude the observer marks the upper or lower edge or *limbe* (from the the Latin word *limbus* an edge or border,) and by subtracting or adding the half of the apparent diameter, at the time of observation, he obtains the altitude of the sun's centre. But here other corrections must be applied, on account of the refracting power of the air, and of the elevation of the observer's eye above the true horizon, both which circumstances make the altitude appear somewhat greater than it really ought to be. When the sun is in the ecliptic, that is, at the equinoxes, in March and September, the sun's meridian altitude subtracted from 90 deg. leaves the latitude of the observer: at all other times his distance from that line on either side, or his *declination* N. or S. must be either calculated, or taken from accurate tables, published in various works, but particularly in the *Nautical Almanack*, printed by the authority of the Board of Longitude. Of these tables and their uses a most useful collection and explanation will also be found in the *Complete Navigator of Dr. Mackay*. For ascertaing the latitude it is always most desirable to obtain the meridian or noon altitude of the sun: but as from the state of the weather or other impediments, this cannot always be done, methods have been devised to arrive at the same result, by two or more altitudes observed at other times of the day. With respect to observations of this kind these general cautions will be useful. The observations ought to be taken between 9 in the morning and 3 in the afternoon:—when both are made in the forenoon, or both in the afternoon, the

interval between them must not be less than the distance of the observation of the greatest altitude from noon:—if the one observation be in the forenoon and the other in the afternoon, the interval between them must not exceed 4½ hours; and in all cases the nearer the greater altitude is taken to noon, the more satisfactory will be the result.

From the exquisite perfection to which astronomical instruments are now brought (and for which indeed to *Dolland*, *Ramsden*, and other admirable artists of our own country the world is principally indebted,) observations of the sun and other heavenly bodies may be made, on sea as well as on land, with all requisite accuracy for determining the latitude of the ship or of the place of the observer. By these means the position of the observer can be correctly ascertained with respect to his distance from the equator and the poles of the earth, that is, to his *northing* or *southing*. To discover the place of the observer, however, on the face of the globe, his distance on either side of some fixed meridian must also be determined; in other words, we must determine his *longitude* as well as his *latitude*, and in this lies the grand difficulty in the practice of seamanship. All places being brought in succession directly to face the sun, by the earth's rotation on her axis, once every 24 hours, each must have in its turn its own meridian line, on which the sun appears at noon, when his apparent altitude is the greatest. But these meridian lines having nothing corresponding in the heavens, their position can never be determined by a reference to any fixed points or objects in the heavens. As the earth turns once round on its axis in 24 hours, and that her circumference at the equator contains 360 degrees, each containing 60 minutes, if we divide this quantity by 24, we have 15 degrees for the motion of the equator in one hour, and consequently 15 minutes of longitude for 1 minute of time, 15 seconds of longitude for 1 second of time, and so on. But as in all places noon or mid-day is the instant when the sun appears to arrive at his greatest elevation, this instant must happen later and later, in proportion as the several places be more and more to the westward of one another. Consequently a place situated 15° to the westward of another, must have the sun at his greatest elevation, or have noon, as much later in time as corresponds to 15°, that is, 1 hour. By the same cause, when the sun has attained his greatest altitude at the western-most place, an hour must have elapsed since he was at his greatest altitude at the eastern-most place, where the inhabitants will be reckoning the time to be one of the clock in the afternoon. Again, when the sun is at his greatest elevation at the eastern-most place, it will require a whole hour before he be so at the western-most, the inhabitants of which, seeing it to want an hour of their noon, will reckon the time to be eleven of the clock in the forenoon. Hence we see that, although the rotation of the earth be equable and constant, yet, to the inhabitants of different spots, common time, the rising and setting of the sun, and the instants when the various appearances of the heavens take place, must all bear a relation to the position of those spots in

easting and westing with regard to one another. Let us now suppose a person possessing a watch that might be depended on to keep regular time for several weeks together, should set the watch precisely to noon at London, and proceed without delay to Naples in the S. of Italy, he would find that the clocks there would point out noon, and the sun be at his greatest height, when according to the watch it was but a few minutes past eleven. Let the traveller, keeping the watch unaltered, go on to Constantinople, he will there find the sun at its greatest height, and the people reckoning noon, when by his watch it is only turned of ten o'clock. By these observations he will learn that Naples having noon nearly one hour, and Constantinople nearly two hours before it would be reckoned noon in London, the first town must be situated in nearly 15 degrees, and the second town in nearly 30 degrees of longitude E. from London. By comparing accurately the differences of time, as indicated by his watch, and as reckoned at those towns, he would find that when it was noon at Naples, it was by him just 11 hours, 2 minutes, 58 seconds, or that the watch gave time 57 minutes, 2 seconds later than was reckoned at Naples. This difference converted into degrees, &c. of longitude, at the rate of 1 hour for 15 deg. will give 14 deg. 18 min. for the longitude of Naples, E. from the meridian of London. Again at Constantinople, he would find noon to happen when his watch indicated only 10 hours, 4 minutes, 20 seconds, being 1 hour, 55 minutes, 40 seconds, before it would be noon at London. This difference reduced into degrees, &c. of longitude, as in the former case, will give for the longitude of Constantinople, 28 degrees, 55 minutes, E. from London. On the other hand, the captain of a frigate, bound for the W. Indies, takes out with him a watch set to the true time at London: but when he arrives at Barbadoes, he finds the sun not to attain his greatest altitude until the watch indicate 3 hours, 58 minutes, 40 seconds afternoon. This difference converted into longitude will give 59° 40′ for the longitude of Bridgetown, the capital of Barbadoes, W. from the meridian of London. The meridian of London is here introduced for example's sake: but every British mariner knows that longitude is by us now reckoned, not from London itself, but from the meridian passing over the Royal Astronomical Observatory, on the hill in Greenwich park, which is sufficiently elevated and remote to command an extended horizon, and to be free from the smoke of London. The cross on St. Paul's church, over which the meridian of London passes, is situated 5 minutes, 47 seconds of longitude, to the westward of the meridian of Greenwich Observatory, to which last all modern maps, charts, tables, and calculations are, or ought to be, adapted. In France, the longitude is reckoned from the meridian of the Royal Observatory, in the S. part of Paris, which lies in longitude, 2 deg. 19 min. 51 sec. E. from the meridian of Greenwich: and in Spain it is counted from the meridian of the Royal Naval Observatory, in the S. part of Cadiz, situated 8 deg. 37 min. 35 sec. W. from Paris, and consequently in longitude, 6 deg. 17 min. 44 sec. W. from Greenwich. By attending to these relative positions, the mariner will be able to reduce the

longitudes of places, in French and Spanish charts or books, to the first meridian adopted in this country. In former maps the first meridian was carried over the W. part of the island of *Ferro*, the most western of the Canary islands, and consequently including the whole of the old continent. This spot is situated in 17 deg. 45 min. 50 seconds of longitude W. from Greenwich.

To engage learned and ingenious men to exercise their faculties in devising some commodious method of ascertaining the longitude at sea, various encouragements have been held forth, by different governments of Europe. So early as in the end of the 16th century, Philip III. who had just succeeded to the throne of Spain, first set the honourable example, which was followed by Holland, France, &c.: and in 1714 the British parliament established commissioners to conduct the business, empowered to grant rewards to a great amount, to be proportioned to the degree of accuracy by which the longitude could be known, by the several projects to be proposed. With an emulation and rivalry highly creditable to all parties, the artists of London and Paris exerted their utmost ingenuity, to approach the desired object. In this contest the names of *Graham, Harrison, Kendal, Arnold*, in England, and of *Le Roy, Berthoud*, &c. in France, will ever be celebrated, who produced watches or chronometers, that is, time-measures, which preserved an uniformity of movement on ship-board, and in various climates, with as much precision as can perhaps ever be attained by any mechanical contrivance of that nature. A marine watch carried round the world by Captain Cook, in the years 1772, 1773, 1774, and 1775, never in all that time, in every vicissitude of climate and motion, erred above 14 seconds in any one day. Another afterwards constructed by Arnold, during a trial of 13 months *upon land*, never varied more than 6¼ seconds in any two days. Admirable however as are these machines, still from their very structure and materials they must be liable to accidents, and may from causes unknown or unperceived, fall into erroneous movements, which the mariner can neither detect nor correct, without reference to some other standard. For this purpose he must have recourse to observations of the heavenly bodies, and the position of the moon relative to the fixed stars, the beginning and end of eclipses, &c. have been proposed. As however it is necessary that a change in the position of the bodies observed should be sensible, in a very short interval of time, (the difference of one minute of time corresponding to 15 minutes of longitude) the most convenient objects for observation are the motions and eclipses of Jupiter's satellites or moons, (See *Astronomy)* for by their number and the short periods of their revolutions round his body, they present a quick succession of eclipses and mutual approaches. Of the various appearances of these satellites, tables have been calculated, for the meridian of Greenwich, which are yearly published by the Board of Longitude; so that by comparing the time when an eclipse or other appearance happens in any part of the world, with the time when it happens at Greenwich, as given in the tables, the difference of time will give the difference of longitude

from Greenwich, E. or W. as the observation is sooner or later than the instant there given. By observations of this kind, the longitude *by land* may be ascertained with all desirable accuracy: but unfortunately for the mariner such observations are, from the unceasing movement of the ship, *at sea*, almost impracticable. On this account, Lunar observations, that is, the measurement of the apparent distance of the moon from the sun, or from some remarkble fixed star, near her path round the earth, are now employed at sea: and the nautical almanack contains tables adapted to the purposes of the calculation. The instruments for lunar observations are, a good watch that can be depended on for keeping time within the error of one minute, for six hours together, and a quadrant of Hadley's construction, or rather a *sextant*, the arch being one-sixth of a circle, and therefore containing 60°, which, by the double reflection produced by the instrument, will measure an angular distance of 120°. By this instrument the image of one heavenly body reflected from the mirror or the index is made to coincide with the other real body, and the number of degrees, minutes, &c. pointed out by the index upon the arch, is the angular distance between the objects, the altitude of each being also observed by assistants at the same instant; and the difference of time, before or after that pointed out for similar appearances at Greenwich, shows the difference of longitude, east or west, from that meridian.

Sea-charts and Maps. These representations of portions of the earth's surface, although intended for different purposes, are constructed on the same principles. The sea-chart contains only the line of the sea-shore, with indications of rocks, sand-banks, currents, anchoring-places, and every other particular that can be interesting to the navigator in conducting his vessel across the pathless deep. On the land no objects are shown, unless it be a remarkable hill, a steeple, a light-house, or other remarkable point of view, by which the seaman can be able to know the coast and to govern his course accordingly. Maps, on the contrary, contain equally the coast-line; but their end is to shew the internal limits and features of the country, with all its component parts, mountains, hills, lakes, rivers, marshes, woods, heaths, arable and pasture lands, cities, towns, villages, churches, country seats, canals, roads, bridges, &c. &c. The map of the world is generally given in two circles, as representing on a plane surface the opposite sides of the globe. In one of these circles it is usual to lay down the Old world, or Europe, Asia, and Africa: the other circle is allotted for the New world, or America. A map of Europe would show the boundaries of every kingdom or state: but a map of Britain should contain the limits of the several counties or shires, and a county-map would exhibit the bounds of each parish. A map of this sort in which one inch would contain the extent of one mile upon the ground, that is, upon a scale of one inch to a a mile, would afford sufficient space to represent not only every village but every farm-house within the county.

The surface of the earth being that of a sphere or globe, no

part of it can be a perfectly level plane: but the difference between those surfaces is too small to be of importance in the map of a district of little extent. Again as the meridian lines meet together at both poles, it is plain they ought not to be laid down as if they were really at equal distances. Should however a map or chart comprehend only a few degrees on each side of the equator, if the meridians are there laid down parallel to each other, no material error will be produced. In such a case the degrees and minutes of latitude may be considered as equal to the degrees and minutes of longitude, and the map or chart is constructed in this way. The number of degrees &c. of longitude to be contained in the draught being fixed on, draw a line near the bottom of the paper, and divide it by the given number of degrees &c. of longitude. At each end of this line erect perpendiculars, upon which set up, from the same scale, the degrees &c. of latitude to be comprised in the draught: join the heads of these lines by another at the top, to be divided exactly to correspond with the divisions of the bottom line. Then by a ruler applied to the corresponding points on the opposite lines, draw others through the beginning of each degree, which will throw the whole into squares, within which the several towns, points of coast, or other objects are to be laid down, according to the tables of latitude and longitude, of which an ample collection is to be found in Mackay's Navigation formerly mentioned. A table containing the positions of some of the principal places on the globe will be found in the following treatise on geography, chap. xiii. In all maps and charts, unless it be otherwise expressed, the upper part of the draught is due N. and the bottom is due S.: nevertheless the principal points of the compass ought to be laid down, in some convenient spot.

As the meridians regularly approach each other from the equator, till they meet in the poles, the space corresponding to a degree of longitude on the equator must be gradually lessened as the latitude is increased. This decrease is uniform and always equal to the sine of the complement of the latitude. Thus a degree of longitude on the equator contains 60 minutes or nautical and geographical miles: but at Gibraltar in N. lat. 36° 7′, the extent of a degree of long. is only 48½ miles; at London in lat. 51° 31′, it is 37¼ miles, at Edinburgh in lat. 55° 58′ it is 33½ miles; and at the lat. of 60°, if the earth were a perfect sphere, a degree of longitude would be precisely 30 minutes, or one-half of the extent on the equator. But although the meridians do continually approach one another, yet they all cross the equator at right-angles, which can never be represented on a plane surface, but on a real globe itself. To remedy this inconveniency it was imagined that, by balancing one error by another of equal but contrary effect, portions of the globular surface of the earth might be laid down with accuracy as to bearing and position, although not to distance and the eye. In draughts of this description the meridians are all drawn at equal distances; but the degrees of latitude are made to increase in extent so as to bear exactly the same proportion to the equal degrees of longitude on the map, as the equal degrees

of latitude actually bear to the unequal degrees of longitude on the earth. The orignal contriver of this scheme was *Gerard Mercator* a native of the Netherlands who, in 1569, published a chart of this sort. To this contrivance the notice of the learned was soon attracted; and in 1599 *Edward Wright* of Cambridge published a treatise written many years before, in which he entered into the true geometrical principles on which such a map was to be constructed. From a comparison of his system with Mercator's maps it appeared that, he had not been duly acquainted with the true grounds of his own process. Mercator still however gives his name to this sort of maps and charts, as well as to the method of ascertaining a ship's place at sea, although founded on the principles first made known by Wright. Were it possible by means of instruments, or by mechanical operations, to determine the longitude of a ship at sea, and out of sight of land, with the same facility and accuracy, as we can discover her latitude, the art of navigation would be as easy and precise as it is at present difficult and precarious. But as all mechanical operations must depend on the persevering uniformity of the machines employed, and that the most faultless machines may, if they really do not, err or vary in the results they afford, these results must always be received with caution. Nor does the state of the atmosphere always maintain such regularity as to allow the necessary observations to be made for determining a ship's place by means of the celestial bodies. Hence various methods, all founded on the principles of trigonometry, plane or spherical, have been invented, which may be employed as checks upon one another, and by which, aided by celestial observations when attainable, the purpose of the mariner can be very accurately obtained. To these different methods different names have been given, descriptive of their nature. These are *Plane sailing*, *Traverse sailing*, *Parallel sailing*, *Middle-latitude sailing*, *Mercator's sailing*, *Oblique sailing*, *Windward sailing*, *Current sailing*.

Plane sailing is the application of right-angled plane trigonometry, to solve problems in navigation, on the supposition of the surface of the sea being an even horizontal plane. In it the meridians are considered as parallel straight lines, and the parallels of latitude as straight lines at equal distances; and the things principally to be considered are these four, viz. the course, the distance, the difference of latitude, and the departure. The course is the point of the compass on which the ship sails, or the angle contained between the meridian of the place sailed from, and the line sailed on by the ship. The distance is the number of miles, &c. sailed by the ship on that course, in a given time. In speaking of miles at sea we always understand the nautical or geographical mile, the same with one minute, or the 60th part of a degree of the globe of the earth. The proportion of this mile to the English standard mile has never been precisely determined: but it is now generally agreed that 60 nautical miles are equal to 69¼, or 69⅕ miles English: this last containing 5280 feet, the former will contain 6094, or 6089.6 feet: 3 nautical miles are a marine league, 20

of which are 1 degree. The difference of latitude is a portion of a meridian between the parallel of the latitude sailed from, and that of the latitude come to. The departure is the distance the ship has reached or departed from the meridian of the place sailed from, reckoned on a parallel of latitude; and it east or west, according as the ship eastward or westward. To have a notion of these particulars, let us refer to fig. 7, in Geometry. Suppose a ship from Yarmouth in N. lat. 52° 37′, represented by the point C, should sail S. E. by E. for 56 miles, she will then be arrived at B. The perpendicular A C is the meridian passing through C, and A B at right-angles to it is the departure or the distance between the meridian of C and that of B. The angle A C B is the course, which is here S. E. by E. or 5 points, or 56° 15′, to the eastward of S.: the angle C B A is the complement of the course, or 33° 45′, and the hypothenuse C B is the distance sailed. Let us now find to what latitude the ship is come, by discovering the difference C A, and how far she has departed from the meridian of C, or the base of the triangle A B. It was already observed that, if the hypothenuse of a right-angled triangle be made radius, the remaining sides become the sines of the opposite angles. We thus proceed.

As Radius	=	90° 00′	=	10.00000
To Sine of A C B	=	56° 15′	=	9.91985
So Log. of course C B	=	56	=	1.74819
To Log. of Departure A B	=	46.5	=	1.66804

Again, for the difference of latitude A C,

As Radius	=	90° 00′	=	10.00000
To Sine-compt. of	=	33° 45′	=	9.74474
So Log. of dist. C B	=	56	=	1.74816
To Log. of diff. of lat. C A	=	31.1	=	1.49290

But Yarmouth at C being in N. lat.	=	52° 37′
and the ship sailing southwardly must be at B in a lower latitude; the difference of latitude must therefore be subtracted	=	0.31
She is therefore come into N. Lat.	=	52° 06′

The course and distance run by the ship are the points commonly given at sea: but it may happen from the roughness of the sea, or some other accident, that the distance has not been accurately measured; at the same time that the course is correct, and that when the

ship arrives at B, she is found, by a good observation of the sun's meridian altitude, to be in N. lat. 52° 06′, and consequently that her difference of latitude from C is 31 minutes. In this case the hypothenuse C B, and the perpendicular A C are both given; but the angle of the course A C B and the departure A B are to be discovered.

Making B C as before radius, A C will be the sine of the angle C B A, which, being subtracted from 90°, will leave A C B for the course: thus.

As Log. of B C distance	=	56	=	1.74816
To Log. of A C D of lat.	=	31	=	1.49290
So Radius	=	90° 00′	=	10.00000
To Sine of C B A	=	33° 45′	=	9.74474
Course A C B	=	56 . 15		

Having thus found the angles, the departure is computed as in the first example: and in general in the triangle A C B containing 3 sides and 3 angles, if any 3 be given, of which 1 must always be a side, the remaining sides and the angles may be calculated.

Traverse sailing. When on account of contrary winds or for some other necessary reason, a ship, instead of keeping onwards in one continued direction, sails upon several different courses, measuring the run upon each, in a given time, as in 24 hours, the irregular or zig-zag track she describes in the water is called a traverse. In order to ascertain her place at the end of the last run, with respect to the place sailed from, her difference of latitude and departure, at the end of each run, is to be calculated as shown in plane sailing. This, however, would be a very tedious business and liable to error. Tables have therefore been calculated and published in proper treatises on navigation, pointing out the difference of latitude and the departure corresponding to any length of distance run upon every point and quarter of the compass, and to every degree of the quadrant. If by some of the courses the ship runs to the N. and in others to the S. the difference between the sums of her northings and southings will give her true difference of latitude upon the whole: and the difference between the sums of her eastings and westings will give her true departure upon the whole courses sailed.

Parallel sailing. The earth being spherical, the meridians crossing the equator and meeting at both poles, instead of being every where equidistant as is supposed in plane sailing, the number of miles between any two meridians on the equator must be greater than that between them at a distance on either side, N. or S.: and the higher the latitude the smaller must be the space corresponding to a degree of longitude. By parallel sailing we are taught to solve problems in which the difference of longitude between two

places, on the same parallel of latitude, their true distance, and the latitude of the parallel are concerned. The space corresponding to a degree, or a number of degrees of longitude, on the equator, is always to the space of a degree, or a number of degrees of longitude, upon any given parallel of latitude, as radius to the sine of the complement of that latitude. Thus Scarborough in Yorkshire, and the island Heligoland, off the mouth of the Elbe in Germany lie both on the same parallel of N. lat. 54° 21': but Scarborough is situated in W. longitude from Greenwich 0° 18', and Heligoland in E. longitude 8° 14': adding these quantities together we have 8° 32' for the difference of longitude between Scarborough and Heligoland. To discover now the real distance in nautical miles between these places, we say,

As Radius	=	90° 00'	=	10.00000
To Sine complement of lat.	=	35° 39'	=	9.76554
So miles in a degree of equator	=	60	=	9.77815
To miles in a degree in lat. 54° 21'	=	35	=	1.54369

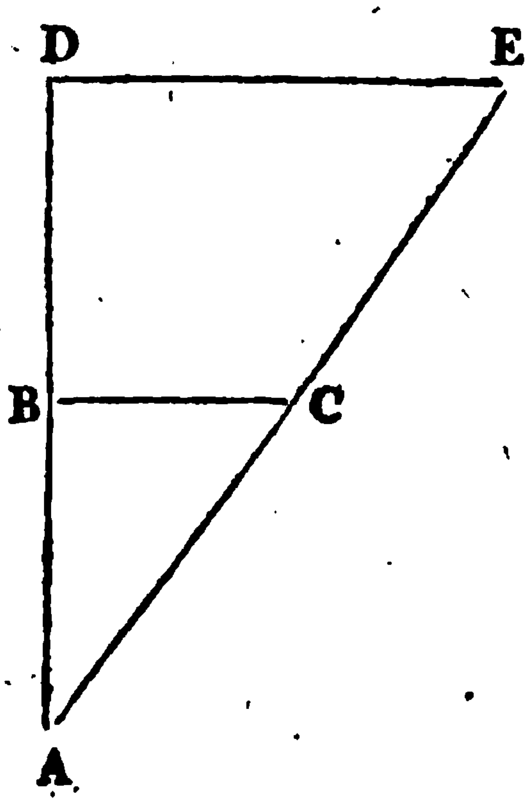
Then as the miles in a degree on the equator 60 to the miles in the difference of longitude 8° 14' = 494, so the miles now found constituting a degree of longitude, in latitude 54° 21' = 35 to 288 miles (equal to 333 English) which a ship must run on a due E. course from Scarborough to fall in with Heligoland, in order to gain the entrance of the Elbe to carry her up to Gluckstad, to Altona, and to Hamburgh.

Agreeably to this problem is computed the length in miles, nautical or English, contained in a degree of longitude at any point of latitude from the equator to the poles.

Middle-latitude sailing is a method of ascertaining a ships' place, when her course is neither due N. or S. nor due E. or W. but in a direction oblique to all. It is so named because, in the calculations, use is made not of the parallels of latitude sailed from, or come to, but of that which lies in the middle, equidistant from both. This method however is not strictly true; for it always gives a result somewhat less than the truth: but in short runs near the equator, and on courses diverging less from the parallel of latitude than from the meridian of the place sailed from, the ship's place may be discovered by it, with sufficient accuracy for ordinary purposes.

Mercator's sailing. It was observed, in touching on parallel sailing, that a degree or any other portion of a parallel of latitude was to the corresponding portion of the equator, as the sine of the complement of the latitude to radius. Analogous to this is the statement that the secant of the latitude is to radius, as the minutes in a degree or other part of the equator to those in a degree or other part of the parallel of latitude. Hence it follows that the meridional parts of any given latitude (that is to say the distance of that parallel from the equator) is equal to the sum of all the

secants of all the minutes in the given latitude, or of other small portions of latitude having a common difference. On these principles are formed tables of the meridional parts constituting a degree and a minute at every point of latitude, by which all nautical questions are solved, and Mercator's charts and maps are drawn. In charts and maps of this construction the parts near the equator differ but little from a plane or a globular chart or map: for although the meridians all converging to a point at the pole, are in no part of their extent parallel; yet in low latitudes their deviation from parallelism upon paper is imperceptible. But the meridians on Mercator's plan being every where parallel, at the same time that the space allotted for the degrees and minutes of latitude is progressively enlarged, the course, distance and bearing between two places may be as accurately laid down or measured on a flat surface, as upon the convex surface of a real globe. But the nature of Mercator's sailing will be better understood by a reference to the annexed figure. Suppose a ship from Yarmouth, in N. latitude 52° 37′, and E. longitude 1° 44′, bound for the Baltic, sail N. E. by N. for 356 miles: required her place in latitude and longitude at the end of her run?



In the right-angled triangle A B C, let A represent Yarmouth, A B the meridian of that place, the angle B A C the course N. E. by N. = 3 points from N. = 33° 15′, A C the ship's track and distance sailed, and C her place at the end of the course, the latitude and longitude of which are to be discovered. C B the parallel of latitude passing through C and B, B A is the difference of latitude between the place sailed from and that come to, and B C is the ship's departure E. from the meridian of A.

To find the difference of latitude A B, we work as shown in Plane sailing, thus,

As Radius	= 90° 00′ =	10.00000
To Co-sine of course, A C B	= 56° 15′ =	9.91985
So distance A C	= 356 =	2.55145
To diff. of lat. A B	= 296 =	2.47130
	4° 56′	

Lat. sailed from N. 52° 37′—merid. parts	=	3726
Diff. of lat. 296 m = 4.56		
57.33—merid. parts	=	4244
A D = Diff. of lat. in merid. parts	=	518

Then producing A B to D, and making A D equal to the meridional difference of latitude now found, 518, as A B the real difference of latitude was made 296, and drawing D E a perpendicular at D, and consequently parallel to the departure B C, until it meet the distance sailed A C, produced in E; then D E will represent the difference of longitude between the points B and C; always greater than B C in proportion as the ship's place is removed from the equator.

As Radius		90° 00′	=	10.00000
To Tangent of course E A B	=	33° 15′	=	9.81666
So Merid. diff. of lat. A D	=	518	=	2.71433
To Diff. of long. D E	=	340	=	2.53099
		5° 40′		

Long. of Yarmouth E.	=	1° 44′
Diff. of long. found	=	5.40
Long. of ship at C	=	7.24 E. from Greenwich.

By this computation therefore it appears that the ship by steering 356 nautical miles N. E. by N. from Yarmouth is arrived in N. lat. 57° 33′, and E. long. 7° 24′, a point a few miles Southeastward of the Naze of Norway, and in the fair way to run E. for the Sound leading into the Baltic.

Oblique sailing, is of particular usefulness in sailing along shore, to determine the ship's distance from one or more points on the land, as also the distance and bearing of those points themselves. Hence it is applied in taking a survey of a harbour, a bay, or tract of sea-coast. Suppose a ship at A, (see fig. 32, geometry) sailing along the coast, observe a light-house on the land at C, bearing by the compass, corrected for variation, N. 35° 40′ E.; and standing on due E. for 5 hours, at the rate of 6 knots in the hour, as along A B, she observes the same light far behind, bearing N. 54° 50′ W.: required the distance between the light and the ship at the several places of observation, A and B.

By subtracting from 180° (two right-angles) the sum of the observed angles at A and B, we obtain the remaining angle A C B: then as the sides of the triangle are always proportional to the sines of the opposite angles, the two sides A C and D C will be found in the following way. The bearing of A C being N. 35° 40′ E. its complement to E, or the angle C A B will be 54° 20′: and the bearing of B C being N. 54° 50′ W. its complement A B C will be 35° 10′: the sum of these two angles 90° 30′ subtracted from 180°, leaves 90° 30′ for the angle A C B.

Then as the sine of A C B	=	90° 30′	=	9.99998
To sine of C B A	=	35° 10′	=	9.76039
So the known side A B	=	30	=	1.47712
To the unknown side A C	=	17.28	=	1.23753

Again, by a similar operation, the side C B will be found $= 24.38$: consequently when the ship made her first observation of the light from A, it was distant N. 35° 40' E. 17¼ miles, and when she made her second observation from B, the light was distant N. 64° 50' W. 24⅓ miles. If by the process exemplified in *mensuration*, the length of the perpendicular C D be found, we shall have the distance from the ship to the light when nearest to it, which, as she sailed due E. must have been when the light bore due N. from her.

Windward sailing. Were a ship or other inert body to be placed in, and acted upon by one substance or medium only, it would remain at rest or move precisely in the direction, and with the velocity of the surrounding medium: thus a log of wood in a river can neither move faster nor slower than the stream in which it is immerged. But if, as is the case with a ship, one part of the body or keel be under water, while the other part and all the rigging are surrounded only by air, the motion impressed on the ship will be compounded of the effects of the action and resistance of these different substances. Her motion through the water will be much slower than that of the wind upon its surface, in proportion to the density of the water; and the action of the wind on the ship must exceed the resistance of the water before she can move at all. From the shape of a ship, narrowing gradually to a sharp edge at the head, and the arrangement of the sails, by which the wind is made to act in a direction inclined to its own, a ship placed in this inclined direction will be pressed forward with a velocity varying according to her construction and management. Suppose now the wind to blow from due N. off a shore stretching due E. and W. and that a ship some miles out at sea can make good her course only at right-angles to the wind, that is, E. and W.; in such a case the ship would sail for ever parallel to the shore, neither approaching to, nor falling off from it. When the water is tolerably smooth however, and the wind permits a proper quantity of sail to be carried, it is found by experience, that a ship will make good her course at an angle with the direction of the wind sensibly less than a right-angle. Let the wind blow from the N. and the ship be able, according to the sea phrase, to lie within 6 points of the wind, that is, to make good her way, either W. N. W. or E. N. E. according to the tack she stands on. By this course it is evident that her course being no longer perpendicular to the wind, but inclined to it in an angle of 6 points $= 67° 30'$, her course being no longer parallel to the shore, she must by continuing to sail on that angle, at last fall in with the land to windward: and by varying her course from W. N. W. to E. N. E. after running to a convenient distance on both tacks or boards, according to circumstances, she may thus gain a port situated directly in the point from which the wind blows.

Current sailing. Although the ocean be confined within certain bounds, unless in the rise and fall of the tides, yet, in many parts, portions of the waters are observed to move in various directions; in some places constantly advancing, in others alternately advancing

and returning upon themselves. These partial motions are called currents, or settings of the waters; and they are partial, not only with respect to the surface, but to the depth of the water: for counter currents are often met with, where the water on the surface sets one way, and at some depth below it sets not only in a different, but even a contrary direction. Of this fact we have an idea from observing the contrary motions of the clouds, carried along by the strata of air moving in opposite directions. A ship in the midst of a current or in a river, and not supposed to be acted upon in any way by the wind, will follow the stream according to its direction and velocity; so that if the stream run 2 miles in the hour, the process of the ship will be the same. Should however the wind be so strong as to push forward the ship at the rate of 2 miles through the water, her motion will now be 4 miles in the hour, and consequently double that of the current. On the other hand, should a vessel have to advance against a stream or current, setting 2 miles in the hour, with a wind in her favour just sufficient to carry her forward through still water 2 miles in the hour, the two opposing forces being equal, neither would produce any visible effect, and the vessel would preserve her position unchanged. Should however the current set down the river 3 miles in the hour, while the wind impelled her only 2 miles, she would evidently be drawn downwards at the rate of 1 mile in the hour: but while the current ran 3 miles in the time that the wind would force her upwards 6 miles, the ship would advance up the river at the rate of the difference of the velocities, or 3 miles in the hour.

It must often happen that a ship's course, neither directly following nor opposing a current or stream, shall cross it at right-angles or at any other angle of inclination: in such cases the ship will neither sail in the direction in which she steers, nor that of the current; but her track will be compounded of both, or in other words, it will be the diagonal of a parallelogram, whose sides are, in magnitude and portion, representatives of the rate of motion and of the direction of the course steered by the ship, and of the setting of the current. Let a ship A (see fig. 11, geometry) steer due E. in the direction of A B at the rate of 6 miles in the hour, in a part of the sea where a current is setting athwart her course in a direction from S. 30° W. to N. 30° E. at the rate of 3 miles in the hour: required the ship's place at the end of a given time, as 3 hours, the distance and the course really made good. In 3 hours the ship would run 18 miles, while the current sets 9 miles: with these two distances, and the complement of the angle of the setting of the current, = 60°, construct the parallelogram A C D B, (see fig. 25, geometry) and draw the diagonal A D. Then will A be the ship's place, at the beginning of the course, A B = 18 miles the distance to which she would have run due E. in 3 hours, in still water, and B her place at the end of that time. On the other hand, had the ship been impelled by the current alone, she would in 3 hours have been carried N. 30° E. 9 miles from A to C. Being however acted upon by both wind and current, in different directions, she

can evidently follow neither, but will obey most the most powerful impulse; her real course then will approach nearer to the direction of A B than to that of A C, and will be represented by the diagonal A D, which is now to be measured in length and direction in this manner.

In the triangle A C D, we have the two sides A C=9 miles, and C D=18, and the contained angle A C D=120°. For C E being perpendicular to D C, D C E is a right-angle = 90°, and E C A is equal to the angle of the setting of the current=30°, wherefore the whole A C D=120°. Now, subtracting this quantity from 2 right-angles=180°, the remainder 60° is the sum of the two angles at the base C A D, and C D A.

Then as sum of sides AC+CD	= 27	= 1.43136
To diff. of sides AC−CD	= 9	= 0.95424
So Tangt. of half-angles at the base	= 30° 00′	= 9.76144
To Tangt. of half their difference	= 11° 6′	= 9.28432

To half the sum	= 30° 00′
add half the diff.	= 11.06
Greater angle C A D	= 41.06
From half the sum	= 30° 00′
subtract half diff.	= 11.06
Less angle C D A	= 18.54

Again, as Sine of C A D	= 41° 06′	= 9.81781
To Sine of A C D	= 120.00	= 9.93758
So C D	= 18	= 1.25527
To A D	= 23.7	= 1.37504

In consequence of the compound action therefore of the wind and the current, the ship will, although with her head pointing due E. in the direction of A B, actually be carried in the 3 hours from A to D, which last point will be her place, distant 23.7 miles from A. If now to the direction of the current A C=30°, we add the angle C A D before found=41° 06′ we have the whole angle formed by the course actually made good, with the meridian passing through A=N. 71° 06′ E. being a little more to the eastward than E. by N. ¾ N.

CHAP. XIII.

GEOGRAPHY.

GEOGRAPHY is that part of knowledge which instructs us in the form of this earth we inhabit, and describes its several divisions into quarters, empires, kingdoms, and states, with their respective boundaries and subdivisions; the relative positions of countries, cities, towns, mountains, rivers, lakes, seas, islands, and all other remarkable objects on the face of the globe. The term geography is formed from two Greek words, signifying in general a description of the earth: and it is divided into several branches, *chorography* a description of a country or region, and *topography* a description of a smaller portion, a parish for instance, a town, &c.: a description of the sea is more properly termed *hydrography*. Of the utility and importance of the study of geography every man's own experience must convince him: without some practical acquaintance with it the ordinary intercourse and affairs of society could not be carried on; and accordingly traces of this study are to be found in the earliest accounts of the human race. Geometry in general was practised by the Egyptians at a period prior to all authentic history; and it cannot be supposed that the art of representing upon a plain surface the situations and relative positions of the principal parts of their own country, and perhaps of the adjoining regions, would not be early introduced. In the Scriptures we are told that Moses, upon approaching the promised land, laid before the rulers of the Israelites a description of the several districts each tribe was to occupy. How this could be satisfactorily, or even intelligibly done, without some map, or draught, showing how each district was situated with respect to the others, to the sea, to the rivers, lakes, and mountains, in the vicinity, it is impossible for us to conceive: and as Moses was versed in all the learning of the Egyptians, from them he most probably drew his skill in geography and map-making. The Phœnicians, the earliest navigators of whom we have any proper accounts, must likewise very early have contrived methods of

laying down the coasts of the countries, and islands, to which, for commercial purposes, they were accustomed to resort. The first account however upon record, of any thing corresponding to our modern maps, is that conveyed to us by our great masters in knowledge of every kind, the Greeks. By their historians we are told that Thales, or rather his successor Anaximander, about 600 years before our Saviour, produced a draught or map, on which were laid down the positions of Greece and its adjoining countries. After Anaximander came a succession of geographers among the Greeks, of whose writings in general only imperfect fragments have come down to our hands. At last in the reign of Augustus Cæsar, about the year 19 of our Lord, appeared Strabo, a native of Amasia in Lesser Asia, near the Black Sea who, profiting by the informations collected by scientific men, employed by Julius Cæsar, the illustrious predecessor of Augustus, composed a general system of geography which has happily been preserved tolerably intire to our days, and which, besides geographical and historical information concerning such quarters of the globe as were then known, many of which the author had himself visited, contains a number of curious enquiries relative to disputed points, and extracts from the writings of his predecessors, which, but for Strabo's works, would now be utterly unknown. Still however was wanting a treatise which, to the informations of Strabo should join the philosophical and geometrical principles on which geography rests as a part of the knowledge of the universe. Such a treatise was produced, 120 years after Strabo, by Claudius Ptolemy of Alexandria, in Egypt, containing directions for the construction of maps, adapted to the globular form of the earth, and to the positions of places in respect to latitude and longitude.

The inconsiderate and uninformed portion of mankind, in modern as well as in antient times, have been of opinion that this earth is a vast extended plane surface, (mountains are here not considered) bounded on all sides by the sea or the heavens. More attentive and sagacious observers however were long ago persuaded that the earth is a round ball or globe, maintaining its appointed station among the innumerable bodies composing the universe, and far removed from contact with any other body, of either the same or a different kind. How the antients came to be convinced of the globular or spherical form of the earth, we have now no means of knowing; but by attending to the following facts we may be easily led to form the same opinion. When we stand by the side of a large piece of water, a lake or an arm of the sea, of several miles in breadth, and fix our eye carefully on such objects on the opposite side of the water as just appear along its surface, if we stoop the eye slowly downwards the objects we saw on the surface, will gradually seem to sink below the water, and at last entirely disappear. On the other hand, if by ascending an eminence, climbing up the mast of a ship, or the like, we raise the eye above its former position, we will gradually discover new objects, rising in succession above the surface of the water, which were not seen before, and which will in

the same order successively disappear below the surface, as we descend to our original station. Again, when a ship leaves the land, the observers on shore first lose sight of her hull, next of the lower sails, then of the upper, till by increasing her distance the whole vessel, sails, masts, and all, disappear from the view, through even the best telescopes. On the other hand, when a ship approaches the land, or another ship at sea, the top rigging is first discovered, and as the distance is lessened, the lower sails are seen, and at last the vessel herself comes plainly into view. These appearances can be accounted for no other way than by supposing the surface of the water to be, not an even level plain, but a portion of the rounded surface of a globe: and the fact may be easily ascertained, by an experiment on any body of a globular shape. In every eclipse of the moon, occasioned by our earth coming in between her and the sun, the shadow on her body is invariably circular; consequently the body thus intercepting the light must be circular in all directions, that is a globe or sphere. Were the earth a circular thin plain, like the head of a table, or thicker, like a drum, as has been supposed, her shadow could not be always of the same shape: but that the earth is a globe or sphere is placed beyond all possibility of doubt, by the voyages repeatedly performed, in every direction, in which no obstacles from land, ice, &c. occurred round the world, from the port of departure to the same port again. Some navigators have performed this voyage, sailing in a general sense always westward: others have done so sailing in a general sense always eastward; and yet both have equally fulfilled their undertaking. Such voyages are therefore utterly inexplicable, unless the seas on which they pursued their course had been spread out upon the surface of a ball or globe.

When the earth was understood to be a sphere, attempts were naturally made to ascertain her dimensions: and it is a matter of wonder how nearly some of the antients came to the truth, considering their ignorance of a great part of the earth, and their want of instruments, such as we now possess, for making those observations on the sun, moon, and other heavenly bodies, by which alone the magnitude of our globe can be properly determined. Two hundred and fifty years before our Saviour, Eratosthenes, a philosopher of Alexandria of Egypt, computed the circumference of the earth to be nearly equal to 25,700 English miles, which is beyond the truth, but which indicates an accuracy of observation and a sagacity of induction of which it is impossible for us, accustomed as we are to multitudes of ingenious helps, to form any adequate conception. When measurements for the purpose of determining the dimensions of the earth were made in these latter times, in places at great distances asunder, the results were so far from agreeing with one another, that enquirers began to suspect our ball not to be a perfect sphere or globe of equal diameter in all directions. If you whirl a key at the end of a string round your finger, the key acquires a motion by which, if not hindered by the string, it would fly off to a considerable distance, proportioned to the length of the string, and to the rapidity with which

it is whirled round. Just such an effect is produced on the globe of the earth in its motion round upon itself once in 24 hours. The parts at the greatest distance from the points round which it turns, going round in the same time with those nearest to those points, must consequently move with much greater velocity. In every revolution of a coach wheel, the nave and the rim move round in the same time; but the circumference of the rim being much greater than that of the nave, any point of the rim must turn round with much greater velocity than any corresponding point of the nave. Hence, if a circle or a ball of soft loose materials were rapidly whirled round upon an axle, the particles would have a tendency to fly off, and would of course swell out and accumulate towards the middle of the ball, gradually leaving the parts near the axle, and, after some continuance of this rapid whirling, the ball which was at first a perfect globe, would by degrees assume a different form, resembling in some measure that of an orange revolving round a wire passing through the middle of its flattened sides. From a consideration of this and some other facts in the nature of things, our immortal countryman Sir Isaac Newton demonstrated that, if the earth were pierced through the centre, by a line from the middle of the flattened sides, it would be about 26 English miles shorter than a similar line carried at right-angles to the first, passing through the swelling surface of the globe: and his doctrine has been admirably confirmed by repeated measurements of parts of the earth's surface. Upon taking a medium of the different measurements and computations of the earth, it appears that, if it were a perfect sphere its axis, in whatever way it passed through the centre, would be about 7930 English miles, making the circumference about 24,913 miles: and the 360th part or one degree will then contain 69.2 English miles. It would appear, however, that where the earth has the greatest diameter, a degree of her circumference from west to east would contain nearly 70½ English miles. If dependance can be placed on the various measurements of various portions of the earth, by men eminent in science, aided by the most exquisite instruments, we will be disposed to conceive it not to be correctly reducible to a figure of any one regular and uniform shape: but these irregularities, although in some very delicate operations of geography, astronomy, and navigation, they may occasion sensible errors, are still too inconsiderable to be noticed in the common business of life. It will have occurred to the reader that when the surface of the earth is described as a globe or sphere, no allowances are made for the inequalities produced by mountains of even the greatest elevation. The highest mountain in Europe is *Mont Blanc*, (so called from its vast mantle of snow descending low down its sides) in the centre of the Alps between Italy and Switzerland: and its perpendicular elevation above the surface of the sea is 15,662 English feet, within 178 feet of 3 English miles. The highest summit of the great chain of mountains running through South America is that of Chimborazo, calculated to rise to the height of 20,600 English feet, wanting only 52 feet of 4 English miles.

The lofty ridges bounding the interior parts of India, probably the most elevated region on the globe, are estimated to be raised, in some points, 25,000 English feet above the level of the sea, or nearly 4¾ English miles. Now, the diameter of the globe being taken at 7930 miles, were it divided into 1654 equal parts, the highest known mountain would contain but *one* of such parts: so that were a globe to be constructed of timber 35 feet in diameter, the highest mountain in the world would not stand more than *a quarter of an inch* above its general surface: in speaking of the globular surface of the earth, therefore, the inequalities upon it in heights and hollows may safely be neglected. (See the heights of the most remarkable mountains, before the article *Europe*.)

When we observe the sun, the moon, and the other heavenly bodies begin regularly to appear, or rise, as we call it, in the east, advance to their greatest elevation, and then sink down and at last disappear or set in the west, it is natural for us to imagine them to be really in motion from east to west, whilst we on the earth are perfectly fixed and motionless. The traveller in a carriage, or in a boat descending a river, moving swiftly forward is apt to think that the trees, houses, and other objects on either hand, are rushing quickly by in a direction contrary to his course. Experience, however, soon corrects this error: in the same way, more extended views of the nature of the visible universe, and of the magnitudes and distances of its component parts, will lead us to account for their apparent motion in a way infinitely more simple, and suitable to the ordinary course of nature. You mount to the top of a hill or other eminence to command a view of the surrounding country. Looking first southerly you turn round by degrees to the west, then to the north, and lastly by the east, back to the south where your view began. By this easy and simple turning round of your person, you have enjoyed a complete prospect of the whole scenery around you, every way as satisfactory as if by some magical power the plains, woods, rivers, towns, and mountains had been rapidly whirled round, in order to bring every object in succession before your eyes, while you remained unmoved at your station. Whether you place the turkey near the fire, or bring the fire to the turkey, the roasting will be equally performed; but to station the fowl immoveable in the centre of the kitchen, and by some ingenious machinery to cause the fire to be carried swiftly round it, until it was fit for the table, is an improvement which, even in these days of ingenuity and refinement, has not yet been attempted. The most learned and expert cook is contented to turn his meat round before the fire, in the same simple manner as was practised by the rudest of his predecessors. Were even the sun, (inconceivably nearer to us than any other fixed heavenly body) to revolve round this earth once in every 24 hours, such is the extent of the circle he would have to travel round, as to demand a rapidity of motion utterly beyond our comprehension. The distance of the sun from the earth is about 95 millions of English miles, the circumference of the orbit or circle in which she would move, will therefore be nearly 597 millions of miles, which, divided by 24, will give nearly 25 millions

for his motion in one hour, or 207 thousand miles for one minute, and even 34 thousand, five hundred, and forty miles for every second of time, that is, between two beats of the pendulum of a common eight-day clock. Now supposing the earth, like the spectator on the top of the hill, instead of requiring the universe to revolve round her, should condescend to turn once round upon herself, all the appearances of the 24 hours would be completely exhibited, and that in a manner admirably simple and easy. The circumference of the earth where greatest, and consequently where in her revolution the parts must move with the greatest velocity, is about 25,420 English miles. A point on her surface therefore in that quarter must, by her turning once round in 24 hours, move at the rate of nearly 1060 miles in one hour, or 17⅔ miles in one minute, or 518 yards (not a third of a mile) in one second. When we consider the prodigious difference of rapidity between these and the former rates, it is impossible that any rational being can refuse his assent to the opinion (were there even no other grounds for it) that the various appearances brought before us in the course of a day are produced, not by the inconceivably rapid circulation of the whole heavens, but by the simple, easy, and comparatively slow turning of the earth itself upon its own axis.

It has been objected to this doctrine that it does not become a limited human being to form conclusions upon his notions of fitness and propriety:—that all exertions of power must be equally within the command of the infinitely powerful author of nature:—that the wisdom by which all natural operations are arranged and conducted is utterly incomprehensible by us, and ought not therefore to become the subject of even our most reverent enquiries.—Such reasoning often proceeds only from pride under the garb of affected humility and self-abasement; from ignorance and indolence under the mask of reverential awe. For if such arguments were permitted to prove any thing, they would infallibly prove too much, nay, a great deal more than would be allowed by those who use them. The only grounds on which rational and considerate beings, in all situations and states of society, can establish their belief in the existence and superintendance of the author of nature, infinite in power, in wisdom, and in goodness, are, and must necessarily be, the admirable fitness, simplicity and energy of apparent causes, to the effects invariably arising from them. When the poor uninformed neglected negro in Jamaica was asked if he knew who made the sun, the sea, the ground and all its varied productions, he answered with a smile of derision, "Made! not made at all master, always so, always so." Experience however had taught him that neither himself nor other animals were immortal. Nor perhaps would it be difficult to find, even in our own enlightened country, individuals who never asked themselves whether the sun that summons them to labour in the morning be the same identical body that sent them to repose the evening before:—that every month of their lives have beheld and heard of new and old moons, without once conjecturing what became of the old, or whence the new were produced.—But to return to our subject:—

An observer on board a ship bound for India in the middle of winter perceives, as he quits the English shore and advances southwards to the Cape of Good Hope, that the sun comes daily more and more over his head at noon, and at last arrives at a point perpendicularly above him. Continuing on his course the sun instead of appearing to the southward, shines from the northward. Having turned round the Cape and the southern point of Africa, he directs his course in general northerly, bringing the sun at noon more and more over him, and at last, before he arrives at Calcutta, has the sun again on his south side, as it was before the traveller left England. This appearance is not peculiar to the sun; for as the traveller proceeds southward he will gradually discover in that direction along the surface of the ocean stars never before visible, whilst others in the northern quarter with which he was acquainted, retire below the horizon from his view. The north pole star itself will, when he arrives at the equinoctial line, sink into the waters behind him, and the stars surrounding the south pole will rise more and more to his view. This will continue until he double the Cape of Good Hope, where, steering northward, the south pole will be lost, and the northern heavens return to his sight. All who have sailed round the earth have followed an eastern or a western course: but were it not for the intense cold accumulating immense bodies of ice upon the seas, in the northern and southern regions of the globe, voyages might be equally performed by courses north or south. These facts establish beyond a doubt that the earth is a globe or spherical body, totally detached from every other body by which it can be supported, like the child's soap-bubble, or the majestic balloon, and maintained in its place in the universe by causes, and agreeably to laws impressed upon it and all the other heavenly bodies, at the moment of their creation.

If through the flattened sides of an orange we pass a long needle or wire, and supporting the two ends of the wire, make the orange revolve round it, we will have an idea (not correct indeed) of the way in which the earth turns upon itself. Not that in the earth any such material axle or axis exists, no more than in the bowl as it rolls along the green: but to this imaginary axis we give a name, borrowed from other machines of which we have a knowledge. The points where this imaginary line comes to the surface of the globe are termed *poles*, from a Greek word signifying to turn round. If this axis be supposed to extend both ways till it seem to touch the surrounding heavens, it will mark out two other points for the poles of the world, as far as regards our earth; for round the imaginary axis extending between these latter points the whole universe appears to revole, while the points themselves remain unmoved. That point which is visible from our side of the globe we call the north pole; and the opposite point, invisible to us is the south pole. If we divide the space between the north and south poles, on the surface of the earth, into two equal parts, and conceive a line to be there drawn quite round the globe an equal distance every where from the poles, it will divide the

globe into two equal parts, hence called *hemispheres*, i. e. half-spheres; and is therefore termed the *equator*. That portion of the earth's surface known to the antients was of much greater extent from east to west than from north to south; for the temperate climates allowing men to spread and penetrate much farther in the directions of the rising and the setting sun, than to the north where eternal snows discouraged all approach; or to the south where, as they thought, intolerable heats rendered it impossible for man to exist. With such ideas it was natural for them to consider the easting and westing as the *length* of the earth, and the northing and southing as its *breadth*. Hence the distance of any place on the globe east or west from a given position was termed its *longitude*, (length) and its distance north and south from a given position was called its *latitude* (breadth.) This latitude was reckoned from the circle begirting the globe, i. e. the equator, and was called north latitude or south latitude according to the position of any place on the north or the south side of the equator; terms still universally employed. The circumference of the globe in all directions being divided into 360 degrees, the distance between the poles contains 180 deg. and that from either pole to the equator contains 90 deg. consequently no place can be in more than 90° of latitude either way. Longitude is not of the same fixed nature, because there is no point fixed on the globe from which it must be reckoned: it is therefore now the practice for the inhabitants of different countries to count from the position of their own capital or other noticeable place. Longitude is reckoned east or west upon the equator; suppose therefore that we in this country choose to count from the position of London, we carry an imaginary line from the north pole over London to the south pole, which will cross the equator in a certain point, from which longitude is to be computed east or west. In former times it was customary to count longitude from a given point quite round the globe to 360°: but later geographers with reason prefer to count one half or 180° eastward, and the other half or 180° westward. The line supposed to extend over London from pole to pole is called the *meridian*, from a Latin word signifying mid-day; because when the sun comes to be upon that line, and consequently to bear due south or due north from the place over which the meridian is drawn, it is then noon or mid-day at that place, and the sun is then at his greatest apparent elevation. The meridian from which longitude is counted is called the *first* meridian: but the smoke of London rendering it an unfit situation for observations of the heavenly bodies, an observatory has been erected on an eminence in Greenwich park, where a regular series of observations has long been carried by astronomers of the first eminence, with instruments not to be matched elsewhere in the world. For this reason it is now the established practice, in all scientific works, to reckon longitude from the point where the meridian passing over Greenwich observatory intersects the equator; and it is thence considered the first meridian for the British empire. In France longitude is counted from the meridian passing over the observa-

tory, situated adjoining to the south side of Paris. In Spain it is reckoned from the observatory of the naval academy in Cadiz.

Latitude being reckoned both ways from the equator for 90 deg. to the poles, if the position of London (that is of the centre of St. Paul's church) be compared with the N. pole and the equator, upon the meridian passing over St. Paul's, it will be found to be 51 degrees, 30 minutes, and 49 seconds to the northward of the equator; consequently St Paul's in London is said to be situated in 51° 30′ 49″ of N. latitude. In the same way, by measuring the arch of the meridian passing over the College of Edinburgh where the observatory is established, intercepted between that place and the equator, the observatory of Edinburgh will be found to stand in N. lat. 55° 57′ 5″. Thus also the observatory of Dublin is in N. lat. 53° 21′ 11″. On the other hand, if a place lie on the S. side of the equator, its latitude is southern: thus the Cape of Good Hope at the southern extremity of Africa lies in S. lat. 34° 29′; and Cape Horn the most southern point of South America lies in S. lat. 55° 58′ 30′, just as far on the S. side of the equator as Edinburgh is on the N. side.

The first meridian of British geographers passes from the N. pole over Greenwich, through the western parts of France and eastern parts into Spain, and across the continent of Africa, traversing the coast of Guinea near Cape Coast castle, and cuts the equator about 8 deg. 14 min. W. from the island of St. Thomas situated close to that line. If we wanted therefore to know the longitude of any place with respect to the meridian of Greenwich, we would carry the meridian of the place in question down to the equator, and there count how many degrees, minutes, &c. were intercepted between it and the first meridian; noting at the same time whether it lay to the eastward or the westward of it. Thus the meridian of the observatory of Paris will be found to cross the equator 2 deg. 19 min. 51 sec. to the E. of the first meridian: it is therefore said to lie in 2° 19′ 51″ of E. longitude from Greenwich. Rome (St Peter's church) will be found to lie in E. long. 12° 29′ 15″. Constantinople in E. long. 28° 55′. Again, Cadiz observatory lies in long. 6° 17′ 35″ west from Greenwich; Kingston, the capital of Jamaica, in W. long. 76° 45′, &c. The difference of latitude between two places is known by subtracting the least latitude from the greatest when both places lie on the same side of the equator; but by adding them together when they lie on opposite sides, because the latitude is counted both ways from the equator. Thus to know the difference of lat. between London and Edinburgh, we subtract the latitude of London 51° 30′ 49″ from that of Edinburgh 55° 57′ 5″, when the difference of lat. is 4° 26′ 16″. In the same way the diff. of lat. between Naples in 40° 50′ 15″, and Petersburgh in 59° 56′ 23″, both lying on the N. side of the equator, is 19° 5′ 8″. On the other hand, to find the diff. of lat. between Portsmouth observatory in N. lat. 50° 48′ 3″, and the Cape of Good Hope in S. lat. 34° 29′ on opposite sides of the equator, we add their quantities together, and the sum

85° 17′ 3″ is the diff. of latitude. Again, to find the difference of longitude between two places on the same side, and within 180 deg. of the first meridian, we subtract the less from the greater; thus the diff. of long. between Paris observatory situated in 2° 19′ 51″ E. long. from Greenwich and Constantinople in E. long. 28° 55′ 5″, we subtract the former from the latter, when the diff. of long. is 26° 35′ 14″. But when the two places lie on opposite sides of the first meridian, the two sums of long. must be added together, for the difference. Thus the diff. of long. between Cadiz in long. 6° 17′ 35″ W. from Greenwich, and Vienna in long. 16° 16′ 22″ E. from Greenwich will be 22° 33′ 57″, &c.

It is here proper to warn the reader that, excepting in a very few instances, the differences of latitude and longitude have no manner of relation to the real lineal distances between places, on the surface of this globe. If both places lie under the same meridian, their difference of latitude will be a proper measure of their distance; as will their difference of longitude, if both lie upon the equator: but in all other positions the relation between the distances of places and their difference of latitude and longitude will be perpetually varying.

The following table contains the latitude and longitude of some of the principal places on the globe; the longitude counted from the meridian of Greenwich.

Places.	Countries, Islands, Seas.	Latitudes.				Longitudes from Greenwich.			
Aberdeen	Scotland	57°	09′	00″	N.	2°	08′	00″	W.
Acapulco	Mexico	17	0	5		101	59	30	
Aden	Arabia	12	40	0		46	13	0	E
Adrianople	Turkey	42	0	0		26	25	0	
Aleppo	Syria	36	11	25		37	10	0	
Alexandria	Egypt	31	13	5		29	55	30	
Algiers	Barbary	36	48	30		3	3	0	
Alicant	Spain	38	28	30		0	28	50	W
Amsterdam	Holland	52	21	56		4	50	30	E
Andrews St.	Scotland	56	19	33		2	50	30	W
Antigua	Caribbee islds.	17	4	30		62	9	0	
Antwerp	Netherlands	51	13	18		4	24	0	E
Archangel	Russia	64	34	0		38	59	0	
Athens	Greece	38	5	0		23	52	36	
Augsburg	Germany	48	21	42		10	58	32	
Avignon	France	43	57	0		4	48	10	
Bagdat	Turkey in Asia	33	20	0		44	22	15	
Balasore	India	21	20	0		86	01	30	E
Bridgetown	Barbadoes	13	5	0		59	40	15	W
Barcelona	Spain	41	23	8		2	10	25	E
Basil	Switzerland	47	33	34		7	35	0	
Bastia	Corsica	42	41	36		9	26	30	

Places.	Countries, Islands, Seas.	Latitudes.				Longitudes from Greenwich.			
Batavia	Java	6°	11′	0″	N	106°	50′	0″	E
Bath	England	51	22	30		2	21	30	W
Bayonne	France	43	29	15		1	28	41	
Belfast	Ireland	54	40	0		6	8	0	
Bergen	Norway	60	23	40		5	11	30	E
Berlin	Prussia	52	31	30		13	23	0	
Bern	Switzerland	46	57	0		7	26	0	
Berwick upon Tweed	Britain	55	47	30		2	0	0	W
Bologna	Italy	44	29	36		11	20	25	E
Bombay	India	18	55	42		72	54	24	
Boston	England	52	58	0		0	3	0	W
Boston	New England	42	25	0		70	37	15	
Bordeaux	France	44	50	14		0	34	15	
Bremen	Germany	53	4	45		8	47	48	E
Brest	France	48	22	44		4	29	59	W
Bristol	England	51	28	0		2	35	0	
Buenos Ayres	S. America	34	35	26	S	58	23	38	
Cadiz Obsy.	Spain	36	31	00	N	6	17	35	
Cairo	Egypt	30	2	21		31	18	30	E
Calais	France	50	57	31		1	51	1	
Calcutta, at Port William	Bengal	22	34	45		88	29	30	
Cambridge	England	52	12	36		0	4	15	
Canterbury	England	51	18	26		1	4	33	
Canton	China	23	8	9		118	16	17	
Carthagena	Spain	37	35	50		1	1	35	W
Carthagena	S. America	10	26	35		75	20	35	
Charlestown	S. Carolina	32	45	0		80	10	0	
ChristopherSt.	Caribee Ids.	17	15	0		62	42	40	
Cape Clear	Ireland	51	19	0		9	23	15	
Constantinople	Turkey in Eur.	41	1	10		28	55	5	E
Copenhagen	Denmark	55	41	5		12	35	10	
Cork	Ireland	51	53	54		8	28	15	W
Cracow	Poland	50	4	0		19	56	0	E
Cromarty	Scotland	57	43	0		4	9	0	W
Damascus	Syria	33	15	0		37	2	30	E
Dantzic	Prussia	54	21	5		18	38	45	
Dartmouth	England	50	21	0		3	42	0	W
Dominica	Caribees	15	18	0		61	28	0	
Dorchester	England	50	42	0		2	26	0	
Douglas	Isle of Man	54	7	0		4	38	0	
Dover, castle	England	51	7	48		1	19	7	E
Dresden	Saxony	51	2	54		13	36	0	

Places.	Countries, Islands, Seas.	Latitudes.				Longitudes from Greenwich.			
Dublin Obsy.	Ireland	53°	21′	11″	N	6°	06′	30″	W
Dunbar	Scotland	56	1	0		2	33	0	
Dundee	Scotland	56	27	0		3	2	30	
Dunkirk	France	51	2	11		2	19	51	E
Durham	England	54	43	45		1	15	0	W
Edinburgh, College	Scotland	55	57	5		3	12	10	
Embden	Germany	53	12	0		7	16	0	E
Ephesus	Turkey in Asia	37	55	0		27	30	0	
Exeter	England	50	54	0		3	34	30	W
Falmouth	England	50	8	0		5	2	0	
Ferro Isle	Canaries	27	47	0		17	45	50	
Finisterre Cape	Spain	42	53	52		9	12	54	
Florence	Italy	43	46	30		11	3	30	E
Flushing	Holland	51	26	37		3	34	9	
Foreland N.	England	51	25	0		1	28	0	
Foreland S.	England	51	8	26		1	22	6	
Funchal	Madeira	32	37	34		17	6	0	W
Galway	Ireland	53	10	0		10	1	0	
Geneva	Switzerland	46	12	17		6	8	30	E
Genoa	Italy	44	25	0		8	56	0	
Gibraltar, at Eur. point	Spain	36	6	30		5	19	31	W
Glasgow Obsy.	Scotland	55	51	32		4	16	0	
Good Hope, Cape	Africa	34	29	0	S	18	23	7	E
Gottenburg	Sweden	57	42	0	N	11	39	0	
Greenwich Obsy.	England	51	28	40		0	0	0	
Grenada	Caribbees	12	2	54		61	51	15	W
Guernsey at S. Peters	Eng. channel	49	30	0		2	52	0	
Hague	Holland	52	3	13		4	16	25	E
Halifax	England	53	43	0		1	52	0	W
Halifax	Nova Scotia	44	46	0		63	27	0	
Hamburgh	Germany	53	34	0		9	55	0	E
Harwich	England	52	11	0		1	13	0	
Helena St.	Atlantic	15	55	0	S	5	49	0	W
Holy-head	Wales	54	23	0	N	4	45	0	
Hull	England	53	38	0		0	33	0	

Places.	Countries, Islands, Seas.	Latitudes.				Longitudes from Greenwich.			
Jersey, at St. Helier's	Eng. channel	49°	12'	59''	N	2°	10'	59''	W
Jerusalem	Palestine	31	46	0		35	20	0	E
Inverness	Scotland	57	36	0		4	15	0	W
St. John's	Newfoundland	47	32	0		52	26	0	
Ispahan	Persia	32	24	34		51	50	0	E
Kingston	Jamaica	18	6	00		76	45	0	W
Kinsale	Ireland	51	32	0		8	50	0	
Kirkcaldy	Scotland	56	8	0		3	10	0	
Koningsberg	Prussia	54	42	10		20	29	0	E
Land's End	England	50	4	7		5	42	0	W
Leeds	England	53	48	0		1	38	30	
Leghorn	Italy	43	33	2		10	16	0	E
Leith	Scotland	56	0	0		3	11	0	W
Lerwick	Shetland Ids.	60	13	0		0	55	0	
Lille	France	50	37	0		3	4	0	E
Lima	S. America	12	1	56		76	54	0	W
Limerick	Ireland	52	22	0		9	53	0	
Lincoln	England	53	15	0		0	30	0	
Lisbon Obsy.	Portugal	38	42	20		9	9	15	
Liverpool	England	53	24	0		3	10	0	
Lizard point	England	49	57	56		5	11	18	
London, St. Paul's	England	51	30	49		0	5	47	
Londonderry	Ireland	54	59	28		7	14	49	
Lyons	France	45	45	52		4	49	9	E
Madras	India	13	4	54		80	28	0	
Madrid	Spain	40	25	18		3	12	0	W
Mahon, Port	Minorca	39	51	46		3	48	30	E
Malaga	Spain	36	43	30		4	25	0	W
Malta at Valetta	Mediterranean	35	54	0		14	28	0	E
Manchester	England	53	26	0		2	15	0	W
Marseilles	France	43	17	45		5	22	8	E
Mecca	Arabia	21	40	12		40	9	0	
Messina	Sicily	38	11	12		15	48	48	
Middleburg	Holland	51	30	0		3	37	35	
Milan Obsy.	Italy	45	28	5		9	11	15	
Montrose	Scotland	56	42	0		2	28	0	W
Moscow	Russia	55	45	45		37	33	45	E
Nankin	China	32	4	40		118	47	0	
Nantes	France	47	13	6		1	33	50	W
Naples	Italy	40	50	15		14	17	30	E

Places.	Countries, Islands, Seas.	Latitudes.				Longitudes from Greenwich.			
Newcastle upon Tyne	England	55°	3′	0″	N	1°	30′	0″	W
North Cape	Lapland	71	10	30		25	57	0	E
Norwich	England	52	41	0		1	20	0	
Oporto	Portugal	41	10	0		8	27	0	W
Ortegal Cape	Spain	43	46	37		7	39	0	
Ostend	Flanders	51	13	55		2	55	45	E
Oxford Obsy.	England	51	45	39		1	15	29	W
Palermo	Sicily	38	6	45		13	23	0	E
Panama	S. America	8	47	48		80	21	0	W
Paris Obsy.	France	48	50	15		2	19	31	E
Parma	Italy	44	48	0		10	20	19	
Pekin	China	39	54	13		116	27	30	
Perth	Scotland	56	23	40		3	27	10	W
Petersburgh	Russia	59	56	23		30	19	16	E
Philadelphia	N. America	39	56	55		75	14	0	W
Plymouth, garrison	England	50	21	22		4	7	24	
Portsmouth observatory	England	50	48	3		1	5	59	
Presburg	Hungary	48	8	0		17	10	30	E
Quebec	Canada	46	47	30		71	10	0	W
Quito	S. America	0	13	27	S	77	55	0	
Rame-head	England	50	18	52	N	4	12	29	
Riga	Russia	57	5	0		25	5	0	E
Rochelle	France	46	9	21		1	9	55	W
Rome, St. Peter's	Italy	41	53	54		12	29	15	E
Rosetta	Egypt	31	24	34		30	28	36	
Rothsay	Scotland	55	50	0		5	17	0	W
Rotterdam	Holland	51	55	58		4	28	0	E
Rouen	France	49	26	27		1	5	44	W
Salisbury	England	51	3	49		1	47	0	
Scarborough	England	54	21	0		0	18	0	
Scaw Light	Denmark	57	44	0		10	37	45	E
Scilly isles S. Agnes' Light	England	49	53	37		6	19	23	W
Seringapatam	India	12	31	45		76	46	40	E
Seville	Spain	37	23	0		5	25	0	W
Sligo	Ireland	54	15	0		8	49	0	
Smyrna	Turkey in As.	38	28	0		27	20	0	E
Southampton	England	50	54	0		1	23	58	W

Places.	Countries, Islands, Seas.	Latitudes.				Longitudes from Greenwich.			
Spurn point	England	53°	41′	0″	N	0°	17′	0″	E
Start point	England	50	13	26		3	38	21	W
Stockholm	Sweden	59	20	31		18	3	35	E
Surat	India	21	11	0		72	22	30	
Teneriffe peak	Canaries	28	17	0		16	38	0	W
Torbay Bury head	England	50	24	1		3	28	14	
Toulon	France	43	7	16		5	56	0	E
Trieste	Istria	45	51	0		14	3	0	
Tunis	Africa	36	45	30		5	33	6	
Turin Obsy.	Italy	45	4	14		7	40	0	
Upsal	Sweden	59	51	50		17	38	40	
Utrecht	Holland	52	5	0		5	6	48	
Ushant Isle	France	48	28	30		5	4	48	W
Valencia	Spain	39	26	0		0	17	0	
Venice	Italy	45	26	7		12	3	15	E
Vera Cruz	Mexico	19	11	52		96	1	45	W
Verd Cape	Africa	14	45	0		17	33	0	
Verona	Italy	45	26	26		11	18	30	E
Vienna Obsy.	Germany	48	12	36		16	16	22	
Vincent St. Cape	Portugal	37	2	54		8	59	26	W
Wakefield	England	53	41	0		1	33	30	
Warsaw	Poland	52	14	28		20	59	54	E
Weymouth	England	50	40	0		2	34	0	W
Whitby	England	54	29	0		0	53	0	
Whitehaven	England	54	25	0		3	15	0	
Worcester	England	52	9	30		1	59	15	
Yarmouth church Norfolk	England	52	36	40		1	44	32	E
York cathedral	England	53	57	45		1	6	45	W
York New	N. America	40	43	0		74	10	0	
Zante	Zante island in Greece	37	48	0		21	20	0	E
Zurick	Switzerland	47	22	0		8	32	35	

The earth turns once round upon her axis in 24 hours, forming one day, during which all points of her surface are successively exposed to the sun's rays and afterwards hid in darkness: but besides this daily rotation she has another motion by which she is carried as in the circumference of a circle round the sun as a centre. This revolution is performed in 365 days, 5 hours, 48 minutes and 49 seconds, constituting our year. Were the axis of the earth exactly perpendicular to a line joining her centre to that of the sun, then his light would shine equally on all parts of the earth, as they turned round towards him, and light and darkness (or day and night) would be of exactly the same length on every day of the year. This, however, is not the case; for on all parts of the globe the length of day and night is continually varying; and this variation becomes more and more sensible in proportion as the place of observation is farther removed, north or south, from the equator. The axis round which the earth makes daily rotation, is inclined to the line joining her with the sun, or to the plane of her orbit or annual course round him, at an angle of 66 degrees 32 minutes; consequently the plane of her equator must form an angle of 23 degrees 28 minutes with that of her orbit. To this simple change in the position of the axis we are indebted, for all the useful and delightful interchange of long and short days, of summer and winter, of spring and autumn;—changes, which in antient times, when the cause was unknown, excited and baffled the utmost ingenuity of the most sagacious inquirers into the operations of nature. By this inclination of the earth's axis, the sun shines, for one half of the year, considerably more on the one side of the equator than on the other: and at two periods of the year, namely at those points where the plane of the equator intersects that of the earth's path round the sun, the day and the night are of equal length, each of 12 hours, all over the globe. This happens about the 20th or 21st of March, and the 22nd or 23rd of September, which on this acount are called the days of equinoxes. Let the elevation of the sun above the horizon be observed at London, with a quadrant, at noon on the 21st of March; it will be 38 deg. 29 minutes. As the season advances towards mid-summer, this meridian altitude will go on increasing, at a certain rate, to the 21st of June, when it will be about 62 degrees, and there remain fixed for a few days. The sun's course toward the north being then apparently stopt, that period is called the summer solstice; and a circle described in the heavens through that point is called the *tropic of Cancer*, from a Greek word signifying to turn back, and from a cluster of stars in that part, called Cancer or the Crab. In a few days after the 21st of June, the sun's apparent elevation at noon will begin to diminish, and so continue till the 22nd of September, when it will be equal to that observed on the 21st of March. This being the autumnal equinox, the day and the night will be of equal lengths: but as the sun's meridian altitude continues to diminish, the day will progressively be shortened, until the 22nd of December, when the altitude will be only 15 degrees. There the sun will again appear to be stationary for a

few days; and that period is called the winter solstice, and the circle described round the south pole of the heavens passing through that point is, from another constellation or cluster of stars called *the tropic of Capricorn*, or the goat. The sun's body being vastly greater than the earth, his light will always enlighten a little more than one half of our globe. At the vernal equinox on the 21st of March, his light extends from the S. to the N. pole: as he advances towards the summer solstice it is evident that his light must extend beyond the N. pole, and continue so to do till the 21st of June, when having proceeded 23½ deg. to the northward, his light must reach 23½ deg. beyond the N. pole, and likewise come short by 23½ deg. of the S. pole. A circle described round the N. pole with a radius of 23½ deg. will point out the extent of his light, and is called *the arctic circle* from a Greek term signifying a bear, the name of a constellation situated at the N. pole. A similar circle described about the S. pole is called antarctic, that is opposite to the arctic. By means of the several circles here described, the surface of the earth is distributed into five *zones*, or girdles. That which reaches between the tropic of cancer, across the equator, to the tropic of capricorn, and consequently in breadth twice 23½ deg. or 47 deg. is called the *torrid zone*, as lying under the intense heat of the sun's perpendicular rays. The zone extending north from the tropic of cancer to the arctic circle, and that reaching south from the tropic of capricorn to the antarctic circle, both in breadth 43 deg. are, from the general nature of the climate, called the *temperate zones*. The spaces surrounding the two poles 23½ deg. in radius, are properly termed the *frigid zones*, on account of the extreme cold prevalent within them.

The surface of the earth is irregularly divided into portions of land and water, the land occupying about one-fourth, and the water three-fourths of it; and by far the greater part of the land lies on the north side of the equator.

It was before observed that the highest known mountains are situated on the northern frontiers of India, in the interior of Asia, and that their most elevated summits rise about 25,000 feet or 4¾ English miles. Mountains soaring above the surrounding plains are obvious to the view, and may easily be measured: it is not so with the depressions of the bottom of the great waters; and it is only by accident that its extraordinary depths can be discovered. The greatest depth of the sea that was ever measured was 5340 feet, or a little more than one English mile, and the mean depth has been estimated at 1300 feet, or a quarter of a mile. In some tracts of the ocean the depths are remarkably uniform; in others they vary both considerably and suddenly: hence it follows that if the sea were dried up, the bottom would present a scene of extensive plains, rugged precipices, and lofty hills, similar to the face of our present dry land. If the whole inhabited parts of the earth be supposed to contain 39 millions of square geographic miles, Europe will contain about 4½ millions, Asia 10¾, Africa 9½, and America 14¼ millions. If the whole population on the face of the globe be estimated at 700 millions, Europe will possess

150 millions, Asia including New Holland and the islands in the ocean, 500 millions, Africa 30 millions, and America 20 millions; so that if the population were equally distributed all over these tracts, each square of a mile every way would contain in Europe about 34 persons, in Asia 46, in Africa 3, and in America 1½, or 3 persons in every two square miles. The reader will, however, be prepared to believe that these statements are in general merely conjectural: for, excepting in the British empire, and two or three other states of Europe, and in the United States of North America, the numbers of inhabitants have never been computed with any degree of accuracy.

The land on the face of the globe is divided into two great portions, the one comprehending those parts which were in some measure known to the antients, and thence called the *Old world*, comprising Europe, Asia, and Africa: the other portion which was in general unknown by the inhabitants of these quarters till the year 1492, and thence called the *New world*, contains America, subdivided into North and South. Besides these vast masses of land which are termed *continents*, because they comprehend a number of distinct states adhering together, innumerable other smaller portions are scattered over the surface of the waters, and inclosed by them, thence called *islands*, such as Britain, Ireland, Jamaica, &c. When a body of land is surrounded by water on all sides but at one point where it is joined to other land, it is called a *peninsula*, a Latin expression, corresponding to almost an island; and the neck of land joining the peninsula to other land is called an *isthmus*. Thus Africa may be considered as a great peninsula, being every where inclosed by the sea excepting at the isthmus of Suez in Egypt, between the Mediterranean and the Red sea, about 70 miles in breadth, by which it is joined to Asia. North and South America are each great peninsulas, united by the narrow isthmus of Darien. A point of land running out into the sea is called a *promontory*, and its extremity is a *cape*, or *head-land*: such are the Land's End and the Lizard in Cornwall, the Spurn at the mouth of the Humber, Fife-ness and Buchan-ness on the E. coast of Scotland. The great body of waters in the midst of which the land seems to float is in general called the *sea* or the *ocean*: but particular portions of it have peculiar names, from their position relative to the land, or other circumstances. Thus the sea extending from N. to S. between Europe and Africa on the E. and America on the W. is called the *Atlantic* ocean from a vast island of that name supposed by the antients once to have existed in the midst of it, but in very early times to have been swallowed up by the waves. The *Mediterranean* sea is properly named, for it lies entirely in the midst of the land, being surrounded excepting at the narrow opening at Gibraltar, by Europe, Asia and Africa. A smaller portion of way more or less inclosed by land, is called a *bay*, as the bay of Biscay, bordered by the W. coast of France and the N. coast of Spain, Torbay, in Devonshire: but when the water runs to a great extent into the land it is often called a *gulf*, as the Adriatic sea, or gulf of Venice. On the other hand, if the

bay reach but a short way within the land, it is usually called a *road*, or *anchorage*, as the Downs on the E. coast of Kent. When an opening into the land is made at the mouth of a river, if small it is called a *creek* or *cove*, if more considerable it is sometimes called a *channel*, as the Bristol channel at the mouth of the Severn. The term channel however, ought more properly to be confined to a narrow sea between two coasts, serving as a *canal* to communicate between two open seas. Thus the English or British channel between England and France, connects the Atlantic and German oceans; St. George's channel forms a communication from a southern to a northern part of the Atlantic, between England and Ireland. In Scotland an opening or arm of the sea, accessible to shipping, at the mouth of a river, is called a *firth**, as the Firth of Forth on the E. coast, the Firth of Clyde on the W. coast of that country, Solway Firth, separating England from Scotland in the vicinity of Carlisle. When two seas communicate by a short narrow pass, it is called a *strait*, or improperly *straits*, as the Straits of Dover between Kent and France, the Straits of Gibraltar between Spain and Africa. In some of the northern parts of Europe a strait is called a *sound*, as the Sound of Mull on the W. coast of Scotland, and the much-frequented passage between Sweden and Denmark, from the German Ocean to the Baltic sea. A body of water entirely enclosed within the land, when of a certain size is called a *lake*, as the lake of Geneva in Switzerland, the lakes in Cumberland and Westmoreland. In Scotland such a piece of water is called a *loch*, and in Ireland a *lough*, (both sounded *loh*,) as Loch Lomond, Loch Tay in Scotland, Lough Neagh, Killarney lough in in Ireland: in some parts of England such waters are termed *meres*, the old Saxon name for a lake, as Winander-mere, separating Lancashire from Westmoreland. The terms *loch* and *lough* are not however confined to inland lakes, but frequently applied to pieces of salt water running far into the land, as Loch Fyne on the W. of Scotland, and Lough Foyle on the N. of Ireland. A large stream of water flowing from the interior of a country to the sea or to some other stream, is a *river*: when smaller, it is a *brook*, or *rivulet*: the term *bourne* or *burn*, forming a part of the name of many places in England, signifies a rivulet or brook, and is in common use in that sense in Scotland, and the north of England. The great and populous quarter of London called Marybone, is styled *St. Mary-le-bonne*, by a ridiculous corruption of the original appellation *St. Mary-les-bourne*, the church of St. Mary on the brook.

Currents.—The waters of the ocean seem in general to be confined to one position; yet in many parts are motions resembling the stream of a river, sometimes on the surface, at others at different depths below it. These motions are called *currents*, and in many cases flow with such force as to require a strong wind to

* This word is commonly, but very improperly, written *frith*, as if it came from the Latin *fretum*, a narrow pass of the sea: whereas *firth* is only a variety of the Norwegian term *fiord*, still employed for an arm of the sea, as in Scotland.

carry a ship against them. When one current is opposed by another in a different direction, the waters are forced into a circular motion called an *eddy* or *whirlpool*, such as the celebrated *Charybdis* at Messina in Sicily, into which mariners were in danger of falling while studying to keep clear of the rocks of *Scylla* on the opposite coast of Italy.

Tides. The sea is besides subject to another motion of great utility for shipping, called *ebbing* and *flowing* or the *tide*, by which it rises and falls twice in 25 hours, flowing in upon the shore and again retiring with great regularity. The nature and causes of the tides were little noticed by the antients, because in the Mediterranean, the sea with which they were best acquainted, tides are neither regular nor considerable. The true cause was first made known by a celebrated German philosopher, Kepler, above two centuries ago: but it was reserved for Sir Isaac Newton to furnish a satisfactory explanation of that important natural operation. He showed that a property existed in nature by which all bodies and all their component particles mutually attract each other, in the direct proportion of the quantities of matter contained in each body, but in the inverse proportion of the squares of their distances asunder. The effect of this property of universal attraction or gravitation is, that the parts of the sea turned directly towards the sun or the moon, are drawn upwards away from the centre of the globe, and are consequently accumulated to a greater depth on the side turned to the moon than on the opposite side. Again, as the solid parts of the globe contain more matter than the liquid, they will be more powerfully attracted by the moon than the liquid, which will in some measure be left behind. Consequently the depth of the waters will be increased on the side of the globe turned away from the moon, as well as on that turned towards her; and as the earth turns round to the moon once completely in 24¾ hours, the waters of the sea will rise and fall twice in that period, as is in fact the case, where the tides flow and ebb regularly. The sun vastly exceeds the moon in magnitude: and would consequently attract the waters much more powerfully: but then his distance is prodigiously greater than her's, so that his real influence is very small in comparison. When the sun and moon are both on the same side of the earth, as at the new moon, or on directly opposite sides as at the full moon, their influence acts conjointly, and then we have the highest or *spring* tides: when the moon is at her 1st or 3rd quarter her action is in some measure destroyed by that of the sun attracting to one side, and then we have the lowest or *neap* tides. Were the globe covered with one uniform mass of water, the periods and heights of the tides would be constantly the same: but the sea is confined by the land in so many parts that the motion of the tides must be, as we find they really are, subject to extreme irregularities. It is therefore from observation, and not from theory, that the times of high and low water, at any particular place, are known. If the moon were fixed in the heavens, a point on the surface of the earth would come opposite to her body once every 24 hours: but as she is in

constant motion from west to east, the same direction with that of the earth's daily revolution on her axis, when the earth has completed the revolution of 24 hours, the moon has advanced so much farther, that the earth must still turn round for 48 minutes more, to bring any point immediately opposite to the moon. Thus, if it be high water at any place to-day at 12 o'clock in the day, to-morrow high water will not happen till 48 minutes later, or within 12 minutes of 1 in the afternoon.

The following table shows the time of high water on the days of the new and the full moons, at some principal sea-ports and other places round the British isles. The first column contains the places, and the second, the hour and minute of high water: when the time is marked 0 hours 0 minutes, as at Alderney, &c. it is understood to be high water at 12 o'clock at noon.

Table of high water at different places on the new and the full moon.

By this table we see that it is high water, at new and full moon, at London bridge, at 3 o'clock; but as the tide takes some time to make its way up the Thames from the sea, the time of high water must happen earlier as we go down the river: conformably to this idea high water happens at Greenwich at 40 minutes past 2, at Gravesend at half an hour past 1, and at the Nore at the mouth of the river, at 12 o'clock. The heights to which the tides rise are very irregular on different coasts. Round Britain and Ireland the tide flows from 10 to 16 feet perpendicular; but in the mouth of the Severn it rises double that height: on the coast of Jersey it rises from 30 to 40 feet, and in the bay of Fundy, between Nova Scotia and New Brunswick in N. America, the tide rushes in with great violence, and ascends to the hight of 60 and 70 feet, accompanied with a loud bellowing noise, from which it has been called the *boar*. As the time of high water falls later every day by about 48 minutes, or three quarters of an hour, the time of high water at any given place, on any day of the moon, may be readily calculated, by adding to the hour on new or full moon 48 minutes for every day of the moon's age. Thus if it be high water at London bridge on the new moon at 3 o'clock in the afternoon, on the 10th day of her age high water will not happen for 10 times 48 minutes, or 8 hours later, that is about 11 o'clock at night.

Winds. The earth is surrounded on every side by a fine elastic fluid substance, commonly called the *air*, but more correctly the *atmosphere*. This air is indispensably necessary for the existence of all animals and vegetables, for conveying light to us from the heavenly bodies, for the use of sight, and for the production of vapours, clouds, dews, and rain. The atmosphere is itself perfectly colourless, and the fine blue tint observed in it, even when beheld in its greatest purity, from the highest mountains, is the produce of vapours floating in it. Air being elastic, that is, endowed with a quality by which it can be compressed into a space smaller than what it usually occupies, and by which, when the pressure is removed, it will not only return to its original bulk, but also swell out and expand itself into a much greater space than it filled at first. Heat which is not merely a state or accident of bodies, but a real material substance, (as is certain from its effects, although we be unable to obtain it in a separate state,) when applied to air, causes it to expand into a greater space; consequently its particles must be removed to a greater distance from one another than before they were heated: the air then becomes thinner, or is *rarified*. On the contrary if heat be withdrawn from air, or it be cooled, the particles will be brought thicker together, or it will be *condensed*. Let us suppose that from any cause acting in a particular quarter of the globe, the air should be heated, and consequently rarified in any considerable degree. The particles of air being thus removed to a distance asunder, will be unable to resist the pressure in all directions of the cold dense air around them, which will therefore crowd into the empty spaces, and thus produce a current of air towards the heated spot, in the same

manner as the water of a river will rush into a pit dug on one side, when a channel is opened for its course. To this stream or current of cold air towards the heated parts, we give the name of *wind*. Suppose the air at Bath and Bristol should be above measure heated, the cold air on the east side would immediately press into its place, leaving a void which would speedily be filled up by air from a point still farther to the eastward. At last the air at London would begin to move westward, and its place being supplied by streams of cold air from Essex, the German ocean, Holland, &c. London would in this case be affected by an easterly wind, but so much later than Bath, as it was farther off from the heated air. Hence we see that an easterly wind has its cause in the west, and its effects are perceived in a direction the contrary to that in which it blows; and so of any other wind. In our temperate climates the winds blow from all quarters: it is remarked however that the south-west winds prevail much more than any other, even upon an average for one third of the year. This wind coming from the warmer regions of the world, joined to our position in the midst of the ocean which never freezes, procures to these favoured islands a moderate temperature of the air unknown upon the continent. The rivers and harbours of Holland, lying in the same latitude with the Thames and the Humber, are usually locked up with ice in winter, while our large rivers and arms of the sea are entirely open at all times in even the most northern parts of Scotland. In warm latitudes the direction of the winds is generally steady and uniform. The parts at and on each side of the equator being much heated, as they roll from W. to E. under the sun, a current of air is produced setting constantly from E. to W. This is most observable between Africa and America: and as vessels bound for the latter quarter are sure to have their voyage expedited by this easterly current of air, it has obtained the name of the *trade wind*. In the sea on the E. coast of Africa, a particular periodical wind called the *monsoon* prevails, blowing one half of the year in general to the S. W. and for the other half year to the N. E. In the warmer latitudes an effect equally serviceable and agreeable is produced by the *sea and land breezes*. These are confined to within a few miles of the shore. The land and air over it being much heated by the sun through the day, the cold air over the sea pushes forward to the shore, and thus brings a current or sea-breeze, enabling ships to run into harbours with day-light and conveniency. On the other hand, as the land is cooled during the night, the air that had been heated and rarified is cooled and condensed; it therefore returns to its place over the land, and what came in from the sea is restored to its former position; thus forming a land-breeze, to carry ships out to sea, although in the night, with perfect safety.

Light. Philosophers have differed concerning light, some asserting it to be a real material substance, others that it was only a chemical effect produced by the action of certain bodies upon one another. Light is so commonly found united with heat, that we are apt to conceive them to be inseparable: yet light is found

in various substances, where no heat can be detected, as in certain putrid animal and vegetable substances, in the glow-worm and some other insects, in the waters of the sea when moved by the oar, or when the waves break along the shore. On the other hand, heat is frequently perceptible where no light can be discovered. The motion of light from any luminous body is so rapid that it was once believed to be instantanious. An eminent astronomer, Römer, however, perceived that when he observed the eclipses and other motions of Jupiter's moons, at a particular time, as on the 1st of March, and did the same six months afterwards, on the 1st of September, there was a difference of 15 or 16 minutes between the times of perceiving the same appearances. As the earth on the 1st of March is just on the opposite side of the sun to her place on the 1st of September, he concluded that the difference of time was occasioned by his distance from Jupiter being greater at the one time than at the other, by the whole breadth of the earth's path round the sun, and therefore that light would be 7 or 8 minutes in travelling the half of that space, namely, from the sun to the earth.

Sound is also produced by the air around us. When a stone is thrown into the midst of a pond of still water, the water suddenly and violently driven from its place by the stone, rises up in a circular ridge or wave round the spot; the water by its own weight soon sinks down into a hollow circle, forcing another wave to rise up; and this alternate rising and falling, diminishing however in bulk, as the wave is removed from the centre where the stone fell, is continued until the force of the original stroke be exhausted. If the impression was considerable, the waves would extend to the edge of the pond, where striking against the banks a second set of circles would be formed, returning back across the first set towards the centre of the pond. Exactly in the same way are impressions made on the air; if a pistol be discharged, the sudden explosion and expansion of the powder will compel the adjoining particles to form a succession of concentric circles, extending to a distance proportioned to the violence of the original impulse. If an observer be within the reach of these circles, he will perceive the motion of the particles of air on his ear, and the sensation of sound will be excited, more or less strong, that is loud, as he is nearer to or farther from the cause. If any solid unyielding bodies, as a high wall, the face of a rock, &c. be placed so near the sounding body, that the circles of air shall strike with some force against them, a fresh series of circles or waves of air will be produced, which in time will extend back to the original sounding body, and the person who fired off the pistol will have his organs of hearing affected by a second sound, which is called *echo*, a Greek term, signifying a sound repeated. By the striking of the air against a number of resisting bodies, a succession of sounds may be produced, and the echo may repeat a sound to a great number of times, as at Simonetta, near Milan, in the north of Italy, where persons of acute ears have perceived the report of a pistol as often as eighteen or twenty times. Sound travels very slowly when

compared with light. By many accurate experiments it has been ascertained that sound moves at the rate of 1142 feet in a second, or 13 English miles in a minute. This motion is of use in determining the distance of objects from which sound proceeds: as for instance, a ship at sea, in distress fires a gun in the night-time; the flash is observed by a person on shore, at 20 minutes past 10, but the report was not heard till 7 seconds afterwards. Sound moving 1142 feet in 1 second, it must in 7 seconds have come 7994 feet, or a mile and a half: the distance of the ship from the shore is therefore ascertained. That sound depends on the state of the air is made manifest by the air-pump, for when the air is exhausted from a vessel, no sound excited within it can be heard. That bodies move or tremble when they produce sound is evident from many circumstances: thus drums, bells, trumpets, violins, &c. may easily be perceived to shake when sounding: and that the air receives impressions of motion from sounding bodies is plain from the common occurrence that bells, empty glasses, the strings of musical instruments, give out sounds, merely from being in the room with other sounding bodies.

Table containing the hight of some of the most remarkable mountains in the world, expressing the method by which their height has been measured.

Mountains.	Height by Geom.	Height by Barom.	Method unknown.
	Eng. Feet	Eng. Feet	Eng. Feet
England.			
Whirnside in Yorkshire, the highest land in England		4052	
Ingleborough		3987	
Pennygent		3930	
Crossfell			3839
Skiddaw	3530	3380	
Snowdon in *Wales*	3568	3450	
Mount Battock			3465
Pendlehill		3411	
Halwellyn		3324	
Scotland.			
Ben Nevis, the highest land in Great Britain		4387	
Ben Lawers			4015
Ben More			3903
Ben Weve's			3700
Shehallien	356[illegible]		

Mountains.	Height by Geom.	Height by Barom.	Method unknown
	Eng. Feet	Eng. Feet	Eng. Fee
Hartfell		3300	
Ben Lomond		3240	
Ben Ledy			3099
Arthur's Seat (Edinburgh)	814		
Ireland.			
Slieve Donard, the highest in Ireland		3150	
Knock Meledown		2700	
Cruagh Patrick		2666	
Nephin		2640	
Mangertown	2500		
Cameragh		2160	
Isle of Man.			
Snafield			1640
France.			
Puy de Sansy			6300
Plomb de Cantal			6200
Puy de Dombe			5000
Pyrenees.			
Mont Perdu		11275	
Mont Canigore		9222	
Sierra Nevada, or Snowy mountains in S. of Spain			
Peak of Muleyhacen		11673	
———Veleta		11398	
Alps.			
Mont Blanc, the highest land in Europe		15662	
Monte Rosa	15084		
Schreckhorn			13000
Mont Buet		10124	
Monte Viso		9997	
Great St. Bernard		10074	
Do. at Convent		8074	
Mont Cenis		9600	

Mountains.	Height by Geom.	Height by Barom.	Method unknown.
	Eng. Feet	Eng. Feet	Eng. Feet
)o. at Post-house		6260	
t. Gothard at Convent		6790	
Apennines.			
Ionte Velino	8397		
Iount Vesuvius at Naples	3938		
Iount Etna in Sicily		10954	
Germany.			
)rtele in Tyrol			13800
omnitz in Carpathian mountains			8640
Brenner			5109
Norway and Sweden.			
Swukku			9000
Aroskutan			6162
Ræetack			6000
Hecla in *Iceland*			5000
Teneriffa, Peak		15396	11424
North America.			
White mountains			4000
Stony mountains			3000
Blue mountains			2000
Blue mountains, *Jamaica*			7430
South America.			
Chimborazo	20584	20280	
Cotopaxi	18600		
Pichincha		15552	
Asia.			
Himmala or snowy range, on the N. of India	25000		

Europe.

Of the four grand divisions of the habitable globe, Europe is by much the smallest. Such however is the general temperature of the climate, the fertility of the soil, the local advantages of even its interior parts with respect to navigable rivers, gulfs, bays, and arms of the sea, by which it is intersected and washed, such is the advancement in all scientific and philosophical pursuits, in arts and in arms, such is the genius of the various forms of government established, such are the fundamental principles and practices of the Christian religion which, under various modifications, is, with the exception of Turkey, universally adopted, such are ability and spirit displayed in manufactures, navigation, and commerce:—— such in fine, are the natural effects resulting from these and other favourable circumstances belonging to the quarter of the globe which we have the happiness to inhabit, that Europe now is, and for ages past has been, in a general sense, the mistress and sovereign of the world.

Europe is situated wholly on the N. side of the equator, between the parallel of Tarifa on the strait of Gibraltar, in N. latitude 36° 2′, and that of North Cape in Lapland, in N. lat. 71° 10½′, the most advanced point towards the N. pole. The extent in longitude is from the meridian of 11° W. from Greenwich including Ireland, to that of 62° E. from Greenwich on the northern borders of Asia. The distance or greatest breadth from North Cape due S. to the island of Candia in Greece, is 2170 geographic or 2500 English miles, and the greatest length from Cape St. Vincent in Portugal in a N. E. direction to the limits of Asia on the Frozen ocean, is about 2850 geographic or 3290 English miles. Within the limits here assigned to Europe, are comprised tracts of sea so extensive, that the land is not computed much to exceed 2½ millions of square miles. Europe is washed on three sides by the sea, on the N. by the Arctic or Frozen ocean, on the W. by the Atlantic, and on the S. by the Mediterranean: the eastern bounding separating it from Asia, is formed by an imaginary line proceeding from the island of Candia, up the middle of the Archipelago, through the strait of the Dardanelles, the sea of Marmora, the haven of Constantinople, and across the Black sea to the mouth of the river Don. Up this river the boundary runs for a considerable distance, and quitting it, crosses a narrow isthmus to the river Wolga, which it follows up for many miles, and then stretches to and along the chain of Ural mountains, and from their northern termination follows the course of the river Cara to the Frozen ocean.

Climate and Soil. The greater portion of Europe enjoys a moderate temperature of the atmosphere; although in the southern parts of Spain, Italy, and Greece, the heat be oppressive, while in the northern regions, the cold is such as almost to prohibit all culture or vegetation. Such however, is the general distribution of air and soil that, from the Baltic to the Mediterranean, cattle and corn,

wine and oil, present themselves in regular and abundant succession.

Inland seas, bays, &c. It is the peculiar advantage of Europe to be indented and penetrated by arms of the sea, in such a way that, excepting towards the Asiatic frontier of Russia, no spot can be found in Europe more than 450 English miles from some sea-coast. On the N. is the *White sea* or gulf of Archangel, communicating with the Frozen ocean. On the W. the *Baltic*, commonly called by seamen the *East sea*, penetrates from the Atlantic all the way up to Petersburgh, separating Sweden and Finland on the N. from Denmark, Prussia, Poland, and Russia, on the S. The *German ocean* separating Scotland and England from Denmark and Holland, may be considered as only a portion of the Atlantic, with which it has an open communication on the N. and a narrow one between Dover and Calais, of 22 miles broad. This last it is reasonable to conclude, has been opened by the violence of the tides and currents, which meet in that quarter, and have gradually worn away the isthmus by which Britain was formerly united to the continent, and by means of which our island was at first peopled with men and other land animals. The *bay of Biscay* is also a portion of the Atlantic, confined by France on the E. and by Spain on the S. Within the strait of Gibraltar the Mediterranean forms several bays on the European shore, of which is that called the Adriatic sea, or the gulf of Venice, from the names of two remarkable cities, the former very antient, the latter more modern, situated at the northern extremity of the gulf, stretching from S. E. to N. W. the whole length of Italy for above 500 English miles, on a breadth of 180 miles in the middle, but narrowing at the entrance to about 40 miles.

Capes, promontories, &c. The most remarkable headlands of Europe are North Cape in Lapland, the Naze at the S. end of Norway, capes Finisterre and St. Vincent, on the coast of Spain and Portugal, Spartivento, and St. Maria, at the S. end of Italy, and Matapan, in Greece.

Mountains. Europe is crossed and bound together by several ranges of mountains, of which the most considerable for extent and elevation is that of the Alps, separating Italy on the E. and S. from France, Switzerland and Germany on the W. and N. Of this vast chain, the most elevated summit, the highest land in Europe, is *Mont Blanc*, (the white mountain,) so named from the unvarying whiteness of its summit and sides, covered with perpetual snows, although the heat in the valleys surrounding its base be in summer very intense. According to the measurements of this summit, by different men of science, and by different methods, it rises to the height of 15,662 English feet, very nearly three English miles, perpendicularly above the surface of the nearest sea, and even 2¾ miles above the lake of Geneva, lying under its northern slopes. *Monte Rosa* another summit of the Alps, situated to the N. E. of Mont Blanc, rises within 600 feet of its majestic neighbour. The *Pyrenees* stretching across the isthmus uniting Spain to France, are in general very lofty, their highest peak towards

the middle, rising 11,000 feet above the level of the sea. The *Apennines*, breaking off from the Alps at the N. W. corner of Italy, run S. E. the whole length of that country. Their highest summit *Monte Velino*, rises 8400 feet above the sea. By a reference to the table before given, the reader will learn the elevation of many other remarkable mountains and summits in different parts of Europe.

Lakes and rivers. Lakes Ladoga and Onega in Russia, those of Geneva and Zurich in Switzerland, the lakes of Garda and Como, Laco Maggiore, in Italy, the lakes of Cumberland and Westmoreland, Loch Lomond, Loch Tay, Loch Ness &c. in Scotland, Lough Neagh, Lough Erne in Ireland, are the most considerable pieces of water inclosed by land in Europe. From these lakes, as well as from assembled springs in the mountains, proceed a number of streams, many of very long course, such as the Wolga, the Danube, the Elbe, the Rhine, the Po, the Loire, the Tagus, which with other rivers of note will be mentioned in describing the countries to which they severally belong.

Political divisions. Peace being at last providentially restored to Europe, and the several nations by whom it is inhabited being, in a general sense, permitted to resume their former systems of government and habits of life, unhinged or overthrown during five and twenty years of unprecedented confusion and calamity, Europe may be again divided into the states specified in the annexed table. The 1st column contains the name of the country; the 2nd its population; the 3rd the name of the capital, and the 4th its population; the 5th the form of government, and the 6th the religion established in each country.

Table of Europe.

Country.	Population.	Capital.	Population	Government.	Religion.
British Isles	13,950,045			Monarchy limited	Protestant
England	8,662,640	London	1,009,546		Episcopal
Scotland	1,697,405	Edinburgh	102,987		Presbyterian
Ireland	3,590,000	Dublin	170,000		Episcopal
Denmark and Norway	2,500,000	Copenhagen	90,000	Monarchy absolute	Lutheran
		Bergen	20,000		Ditto
Sweden	3,000,000	Stockholm	80,000	Monarchy	Greek church
Russia in Europe	33,000,000	Petersburgh	140,000	Ditto absolute	Presbyterian
Holland	2,000,000	Amsterdam	212,000	Monarchy limited	
German states	4,126,000				
Saxony	1,896,000	Dresden	50,000	Ditto	Lutheran
Hanover	850,000	Hanover	15,000	Ditto	Ditto
Hesse	750,000	Cassel	22,000	Ditto	Ditto
Mecklenburgh both duchies	330,000	Schwerin and Strelitz		Ditto	Ditto
Brunswick	170,000	Brunswick	22,000	Ditto	Ditto
Hamburgh	120,000	Hamburgh	100,000	Republic	Ditto

Country.	Population.	Capital.	Population	Government.	Religion.
Lubeck	45,000	Lubeck	30,000	Ditto	Ditto
Wurtemburgh	1,181,372	Stutgard		Monarchy limited	Ditto
Bavaria	3,231,000	Munich	38,000	Ditto	Roman Catholic
Prussia	8,000,000	Berlin	140,000	Monarchy absolute	Lutheran
Poland	12,000,000	Warsaw	65,000		Roman Catholic
Austrian dominions	24,000,000	Vienna	254,000	Monarchy limited	Ditto
France	25,000,000	Paris	600,000	Ditto	Cath. and Protest.
Switzerland	1,630,000			Republics	Do. and Do.
Portugal	3,500,000	Lisbon	200,000	Monarchy absolute	Roman Catholic
Spain	10,400,000	Madrid	165,000	Monarchy	Ditto
Italy	11,500,000				
Lombardy, &c.	3,500,000				Ditto
Roman state, &c.	3,000,000	Rome	160,800	Popedom	Ditto
Naples	5,000,000	Naples	370,000	Monarchy limited	Ditto
Italian isles					
Sicily	1,650,000	Palermo	100,000	Ditto	Ditto
Sardinia	520,000	Cagliari		Monarchy absolute	Ditto
Corsica	167,000	Bastia			Ditto
Malta	60,000	Valetta			Ditto
Turkey in Europe	9,800,000	Constantinople	550,000	Ditto	Mahometan

I. Britannic Empire.

The British empire in Europe comprehends the great islands of Britain and Ireland, with the Shetland, and Orkney, and Western islands of Scotland, Man, Anglesey, and Wight, with others of less note on the coasts of England and Ireland, and Jersey, Guernsey, Alderney, &c. on the coast of France; to which must now be added Malta and its dependant isles, in the Mediterranean sea. The island of Britain lying opposite to France, Holland, and Denmark, extends in length from the parallel of the Lizard in Cornwall, the most southern point of land, in N. lat. 49° 58′, to the northern extremity of Scotland, in N. lat. 58° 46′: the greatest breadth of the island is between the meridian of Yarmouth in Norfolk in E. long. 1° 44′ 22″, and that of W. long. 6° which includes the most westerly parts of Scotland. The length from S. to N. upon the meridian of the Lizard, to the N. point of Scotland (exclusive of the Orkney and other islands) is therefore 528 geographic, or 610 English miles: but the breadth is very irregular: from the extent along the British Channel from the Land's end in Cornwall to the S. Foreland in Kent, is about 312 English miles, while at Carlisle and Newcastle, the distance from sea to sea is only 70 miles, and in the middle of Scotland, so much is the island contracted by the opposite firths or arms of the sea, of the Forth and the Clyde, that the distance from sea to sea does not exceed 25 miles. Of this circumstance advantage has been taken to open a canal across the isthmus, on a very large scale, capable of transmitting sailing-vessels that draw less than 8 feet of water, which is the least depth of the canal, on a breadth of 56 feet, and a length of 35 miles. To the northward of this narrow isthmus Scotland again swells out to a breadth of 160 miles.

Name. This island in the most antient accounts is called *Albion* and *Britannia:* the latter always employed by Julius Cæsar, from whom we have received not the first, but the most accurate account of our native land. The modern appellation *Great Britain*, is not a little preposterous; for it appears to have been assumed, not to indicate the magnitude or the importance of the noblest island on the face of the globe, but to distinguish it from a province in the western corner of France, to which a body of British refugees passed over in the 5th century, and which from them acquired the name of *Britannia*, afterwards corrupted into *Bretagne*. By the Greeks the British isles, or the southwest parts of Britain, are often indicated under the general name of *Cassiterides*, because from them they understood the *tin* was drawn by the navigators of Tyre and Sidon. The purple or scarlet of these places is celebrated in the earliest histories sacred and profane. This precious colour was given out to be the product of a kind of shell-fish found on the coast of Phœnicia. Such a muscle is certainly to be seen there: but if the whole inhabitants of the country had been employed in nothing else but to collect those fish, and extract from them the purple liquor, they could not have dyed twenty yards of cloth in a

twelvemouth. The use of a dissolution of tin, as a mordant or preparatory ground for dying scarlet, was either entirely lost; or never known in Europe till 1543: but as the antient Phœnicians are acknowledged to have made greater progress in many arts, than any other nation, it is not improbable that, by some fortunate accident, they might have discovered the value of tin in preparing the precious Tyrian purple. The liquor of the purple muscle probably furnished the first dye of that sort: and it was the natural policy of the Phœnicians to allow the world to believe that very rare shell-fish to be the only source from which their inestimable purple could be procured. The scarcity of the fish was notorious: and it was the manifest interest of the Tyrians to keep up the price of their commodity, on that account, long after they were able, by the application of tin, to furnish their purple and scarlet, accessible only to the kings and great men of the world, at a comparatively very low price.

The island of Britain is divided into two parts, once separate, independent, and too generally hostile kingdoms, but for these two centuries happily united under one crown, and for these hundred years, conjoined into one common state and kingdom. The southern position is called in legislative acts, *South Britain* or *England*, and the northern is styled *North Britain* or *Scotland*.

England.

England including Wales, is of a triangular form, its length upon the meridian, from Berwick upon Tweed to St. Alban's head in Dorsetshire, being 356 English miles, and the base along the English Channel 312 miles. The superficial area is computed by the map to be 49,000 square miles: but according to the returns of the several counties lately made to parliament, England proper contains 33,204,055 acres, and Wales 4,705,400 acres, making in all 37,909,455 acres, equal to 59,233½ square English miles. If the population of England, as contained in the following table, be 8⅔ millions, the average will be 146 for each square English mile.

Alphabetical table of the counties of England and Wales, stating the number of parishes, acres, and inhabitants in each, with the names and population of the chief towns.

Counties.	P.	Acres.	Inhabits.	Capitals.	Inhabs.
Bedford	124	307,200	67,350	Bedford	3,600
Berks	140	438,797	115,000	Reading	9,800
Buckingham	185	518,400	111,400	Buckingham	3,200
Cambridge	163	443,300	89,346	Cambridge	10,127
Cheshire	101	676,000	192,853	Chester	16,140
Cornwall	161	758,484	188,269	Launceston	3,260
Cumberland	58	970,240	117,230	Carlisle	12,531
Derby	106	720,640	161,142	Derby	13,043
Devon	394	1,600,000	343,000	Exeter	18,896
Dorset	248	775,000	115,319	Dorchester	4,260
Durham	113	610,000	160,000	Durham	8,000
Essex	408	1,240,000	228,214	Chelmsford	4,280
Gloucester	280	800,000	162,560	Gloucester	8,160
Hereford	176	781,440	89,191	Hereford	6,855
Hertford	135	451,000	95,577	Hertford	2,740
Huntingdon	78	210,000	49,500	Huntingdon	3,488
Kent	408	832,000	220,000	Canterbury	9,180
Lancaster	62	1,120,600	672,000	Lancaster	6,500
Leicester	200	560,000	131,180	Leicester	23,446
Lincoln	630	1,893,120	208,557	Lincoln	7,420
Middlesex	200	217,600	830,124	LONDON	
Monmouth	127	352,000	45,582	Monmouth	4,700
Norfolk	660	1,094,400	273,512	Norwich	37,256
Northampton	336	550,000	131,268	Northampton	7,460
Northumberland	460	1,267,200	158,000	Newcastle	27,587
Nottingham	168	480,000	140,500	Nottingham	34,253
Oxford	280	450,000	112,682	Oxford	12,931
Rutland	48	105,000	16,356	Oakham	1,350
Salop or Shropshire	170	890,000	167,329	Shrewsbury	18,543
Somerset	482	1,000,000	275,150	Taunton	5,900
Southampton or Hampshire	253	1,212,000	224,000	Winchester	5,820
Stafford	181	780,800	149,148	Stafford	4,250
Suffolk	575	800,000	210,431	Ipswich	13,670
Surrey	140	481,947	269,125	Guildford	2,700
Sussex	312	933,360	161,311	Lewes	5,820
Warwick	158	618,000	208,190	Warwick	3,750
Westmoreland	26	540,160	41,618	Appleby	2,200
Wiltshire	304	187,000	185,520	Salisbury	7,820
Worcester	152	540,000	138,200	Worcester	13,814

Counties.		Par.	Acres.	Inhabits.	Capitals.	Inhabs.
York	N. Riding	563	1,311,187	155,060	York	18,217
	W. ——		1,568,000	565,200		
	E. ——		819,000	140,500		
England		9,780	33,204,055	8,117,094		
N. Wales	Anglesey	74		33,806	Beaumaris	
	Cærnarvon	68		41,521	Cærnarvon	
	Denbigh	57		60,352	Denbigh	
	Flint	28		39,622	Flint	
	Merioneth	37		29,506	Bala	
	Montgomery	47		49,978	Montgomery	
S. Wales	Brecknock	61		33,633	Brecknock	
	Cærmarthen	87		67,317	Cærmarthen	
	Cardigan	66		42,956	Cardigan	
	Glamorgan	118		71,525	Cærdiff	
	Pembroke	145		56,280	Pembroke	
	Radnor	52		19,050	Presteign	
Wales		840	4,700,000	545,546		
Total		10,600	37,904,055	8,662,640		

In the year 1700 the whole population of England and Wales was estimated at 5,512,000, and in 1750 at 6,523,000: the population of London in 1700 was said to be 674,350, a computation certainly much above the truth, for in 1750 it had risen no more than to 676,750 persons, notwithstanding the great increase of the town, in consequence of the stability of the government, and the vast augmentation of trade and commerce. By the returns to parliament in 1813, the whole inhabitants of London, including Westminster and Southwark, with their suburbs, amounted to the prodigious multitude of one million and ten thousand souls.

Climate and soil. The climate of England is much more temperate than might be expected from its situation on the globe. Being in an island, no wind can reach this country without crossing the sea, which is always of a temperature much more equable than the land, at one time scorched with heat and drought, or at another covered with snow and ice. From this situation proceeds the general humidity which may, by interrupting perspiration occasion sundry distempers, but bestows and maintains on the vales and the hills of England, a verdure and a luxuriancy of pasturage, in vain to be looked for in countries enjoying more genial climates. The medium heat at London for 9 years 1772—1780, was nearly 52 degrees of Fahrenheit's thermometer: but in July 1808 it was very intense; for on the 1st day of that month, the

thermometer exposed to the north-east, stood at 53 degrees, on the 12th it rose to 88½ deg. and on the 14th to 93 deg. The soil of England although much diversified, is generally fertile, and agriculture in all its branches has long been cultivated with such skill and ardour as to bring the corn and cattle to very high perfection. For a number of late years however it has been necessary to import grain from other countries, as often as the state of the war would allow it to be done, notwithstanding that, by some strange infatuation, in England alone, exclusive of Wales, no less than six millions of acres, or nearly one-fifth of the whole country might be considered as waste and unproductive, although perhaps not one million may be really incapable of improvement. Horticulture or gardening, especially in its ornamental branches, has long been cultivated in England with greater attention to the nature of the country than in any other quarter of the globe: and on the continent of Europe an *English garden* is the object of ambitious imitation among all lovers of rural beauty.

Mountains. In a general sense England may be regarded as one extended plain, with the exception of the north-western counties, which in some measure unite with the mountainous region of Wales. The chief eminences in these counties are specified in the table formerly given.

Rivers. The principal rivers in S. Britain, proceeding from the Tweed, which, for about 16 miles up from the sea at Berwick, forms the boundary with N. Britain, down the E. coast, and up the W. coast to the Solway at Carlisle, are these; 1. The Tyne, which, facilitating the great coal and other trade of Newcastle, falls into the German ocean eight miles below that town. 2. The Tees, which, separating the counties of Durham and York, is lost in the same sea below Stockton. 3. The Humber, which is rather an arm of the sea than a river, formed by the junction of various streams, of which the chief is the Trent, falls into the sea below Kingston, commonly, but improperly called Hull. 4. The Thames, which rising in Gloucestershire, and flowing in general eastward, passes by Oxford, Reading, and Windsor, meets the tide a little below Kingston, twelve miles above London, forms the station for the prodigious shipping and commerce of the metropolis of the British empire, and gradually opening its channel, unites with the German ocean 80 miles lower down. The whole course of the Thames is about 140 miles. 5. At the spot where the Thames falls into the sea, it is joined at Sheerness on the right by the Medway, which, rising in Surrey, flows by Tunbridge, Medstone, and Rochester, to the great naval station of Chatham. 6. The southern provinces of England are too narrow to furnish streams of much importance, but many of these by admitting the tide furnish excellent havens for commercial shipping. The Severn, the first river on the W. coast, rising in the heart of Wales, describes a circuitous course by Shrewsbury, Worcester, and Gloucester, after which, opening into the wide estuary or firth called the Bristol channel, it opens a commodious conveyance for the commerce of that town and the surrounding provinces. 7. The Mersey flowing S. W.

from the borders of Yorkshire, conveys the vast manufactoral products of Manchester and Lancashire to Liverpool, the great commercial emporium of the West.

Lakes. The lakes or meres of Cumberland, Westmoreland, and Lancashire, are more remarkable for their romantic and picturesque beauties than for their extent. The meres of Lincolnshire, Huntingdonshire, &c. are not properly lakes, but fenny inundations produced by the stagnation of waters on a country of singular flatness, and too little raised above the surface of the sea to admit of its being effectually drained.

Mineral productions. The tin mines of Cornwall are esteemed the richest in the world: their value in the opinion of the Phœnicians was already noticed. Copper is found in various places, but particularly in the isle of Anglesey, where the Parys mountain yields it in such abundance as to be procured, not in the ordinary way of mining, but by cutting the ore out of its bed as stone is dug from the quarry. This rich mass was little noticed till 1768: but from some vestiges of antient works about it, the Romans are believed to have been acquainted with it. Lead is found in abundance in Derbyshire, in the Mendip hills in Somersetshire, in Cumberland, &c. Iron, at once the most useful and the most extensively distributed of all metals, abounds in Gloucestershire, Shropshire, Lancashire, and other districts: and the invaluable mineral coal is bestowed with a liberal hand in the northern and western provinces of the kingdom: and besides the common services drawn from coal as fuel, to it we are indebted for the great improvements made in converting the metals into various forms, and for the operations of machinery by which our manufactures have been carried to a point of perfection unequalled in any other part of the globe. Certain calculators have charitably warned us that some of the principal stores of coal, particularly about Newcastle, are so far exhausted that, in the course of two or three hundred years, Britons will be compelled to subsist upon the milk of their herds and flocks, for want of a good coal fire to dress the meat. Such however, is the selfishness of these degenerate days, that none can be engaged to deprive themselves of the comforts of a warm fire-side, in order to leave to their posterity as much fuel as will serve to prepare their necessary food. That certain veins of coal have been exhausted, or are drawing to an end, cannot be disputed: but on the other hand, fresh stores are from time to time discovered, particularly in Scotland: so that whether the predictions of scarcity and want be well or ill founded, neither the desponding prophets nor their hearers are likely to witness the fulfilment of their predictions. Salt of an excellent quality, from mines and springs in different quarters, of which those of Northwich in Cheshire are the most remarkable; much salt is also made, where coal can be easily procured, by evaporating and crystalizing sea-water. The northern and western parts of England abound in excellent stone for building: and in the south, the quarries of Purbeck and Portland have long been known. Mineral waters, possessing very salutary powers, are frequent throughout the

country: those of Bath, Bristol, Cheltenham, Buxton, Harrowgate, Scarborough, Epsom, Tunbridge, are the most esteemed.

Animals. These are too well known to need specification: the wolf and the wild boar have long disappeared from our forests; but the large wild cat is still found in solitary districts. Of birds, from the eagle to the wren, as far as eight and forty kinds have been counted up; and the bustard the largest of all, may yet be met with on the open plains of Wiltshire and Lincolnshire. Of reptiles the viper alone ought to be considered as venomous. The situation of England in the midst of the waters affords plentiful supplies of excellent fish. The enormous whale is no stranger on our shores: but the cod, and especially the herring are, or at least ought to be, the means of great national advantage. As a proof of this, we have only to consider that before the late disorders in Europe, the laborious and frugal Hollanders came to fish upon the eastern and northern shores of our island, cured what they caught with salt often procured from our manufactories, provided for a suitable profit on their industry, and after all furnished a better commodity, and at a lower price than could be, or at least than was done by our own fishermen in their own harbours.

Vegetables. Many parts of England still retain the name of forests, although now almost stripped of their trees. Many noble woods however still exist; and the zeal for plantations of the most useful timber prevails in every quarter. Vines were formerly raised in considerable quantities in various parts. In 1086 a vineyard of 6 acres, at Rochford in Essex, yielded 20 casks of wine. In 1156 the vale of Glocester was renowned for its excellent apples, and for its grapes, from which wine was made, not much inferior, as historians say, to those of France. If this was really the case, it proved not so much the goodness of our wines, as the want of skill and management in the French, who knew not how to avail themselves of the advantages afforded by their climate and soil, both peculiarly adapted to the production of the most delicious wines. Some years ago a vineyard was planted for the purpose of making wine, on the warm southern slopes of the isle of Wight in Hampshire.

Scotland.

This portion of Britain is of a very irregular form: the most southern point is the Mull of Galloway, a promontory on the Irish sea, in N. lat. 54° 44′, but on the E. side of the island at Berwick, the boundary with England lies in N. lat. 55° 48′. The most northern point of Scotland at Dunnet head, lies in N. lat. 58° 40′. The most eastern point is Buchan-ness near Peterhead, in W. long. 1° 46′, and the most western point of the continent is at Ardnamurchan in Argyleshire, in W. long. 6° 10. The greatest extent from N. to S. is about 230 geographic, or 272 English miles, and the greatest breadth from E. to W. about 140 geographic, or 162 English miles, while in the middle of the kingdom, as before observed, the distance from sea to sea is only 25 miles. Agreeably

to reports lately made to parliament, the population of Scotland amounts to 1¾ million, and the whole country, including its multitude of islands, is computed to contain about 27,000 square miles, giving an average of 66 persons to one square mile. The vast ranges of lofty rugged mountains with which at least one half of the continent, and nearly the whole of the islands are covered, occasion this small average population; for the low country is well peopled; as for instance, the county of Fife contains 97,256 inhabitants on 480 square miles, or above 200 upon each mile at an average. In the county of Bedford in England, which is just of the same extent, the population is only 67,320, or 140 on a square mile. The following table contains the names of the counties and chief towns in Scotland, with the population of each, agreeably to the latest calculations.

Table of Scotland.

Counties.	Inhabits.	Capital
Aberdeen	128,286	Aberdeen
Argyle	71,860	Inverary
Ayr	87,220	Ayr
Bamff	36,185	Bamff
Berwick	32,100	Dunse
Bute	12,240	Rothesay
Caithness	23,270	Wick
Clackmannan	12,750	Clackmannan
Cromarty	4,060	Cromarty
Dumbarton	24,170	Dumbarton
Dumfries	56,180	Dumfries
Edinburgh, or mid. Lothian	148,566	EDINBURGH
Elgin, or Moray	27,400	Elgin
Fife	97,256	Cupar
Forfar, or Angus	103,870	Forfar
Haddington, or E. Lothian	31,100	Haddington
Inverness	75,220	Inverness
rdine, or Merns	28,240	Bervie
ss	7,480	Kinross
udbright	30,170	Kirkcudbright
k	165,750	Lanark
gow, or Lothian	19,854	Linlithgow
[illegible]	8,720	Nairn
Orkney and Shetland	47,500	Kirkwall Lerwick
Peebles	9,254	Peebles
Perth	129,368	Perth
Renfrew	83,500	Renfrew
Ross	53,190	Dingwall
Roxburgh	35,756	Jedburgh
Selkirk	5,500	Selkirk
Stirling	52,764	Stirling
Sutherland	23,160	Dornoch
Wigton, or Galloway	24,700	Wigton
Total	1,097,405	

The population of Scotland has been rapidly increasing for a series of years back. For example, the county of Fife before mentioned, which now contains 97,256 inhabitants, in 1755 counted only 81,570, and in 1800 about 93,700. In the same year 1755, Edinburgh contained only 57,195 inhabitants: in 1800 they were increased to 82,560, but now (1814,) the number is augmented to 103,000. The growth of population in Glasgow is still more rapid: for in 1707, when the union took place between Scotland and England, the inhabitants were only about 14,000: in 1791 they amounted to 41,777, and in 1806, to 86,630, having more than doubled in 15 years: this year Glasgow contains nearly 101,000, making it the third in population in Great Britain.

Climate and soil. The western shores and islands of Scotland are subject to frequent rains: but the eastern parts are less exposed to moisture than the corresponding provinces of England; and the winters are more remarkable for the quantity of snow than for the severity of the frost. The mountainous tracts are computed to occupy one-half, or rather two-thirds of the whole country: and a semicircular line beginning at the mouth of the Clyde, then sweeping E. and N, by Stirling and Perth to Inverness, would separate the Highlands on the W. from the Lowlands on the S. and E. The mountains are in general adapted only for pasture and forest-ground: but the Lowlands afford many tracts which, by the nature of the soil, and the skilful industry of the inhabitants, furnish excellent crops of every kind of grain. It is not many years since wheat was imported in large quantities into Scotland: but now, notwithstanding the increased population, and the more than proportionable consumption of that grain in the country, Scotch wheat is one of the standing articles introduced into the markets of London, and other ports of England.

Mountains. The highest land in Scotland, and indeed in Britain, is the insulated mountain Ben Nevis in Inverness-shire, rising to an elevation of 4387 feet. The great range of mountains stretching from S. W. to N. E. from the mouth of the Clyde to the vicinity of Aberdeen, has obtained in history the name of the *Grampians:* but no part of that range either now is, or probably ever was known to the inhabitants by any similar or corresponding appellation. The Cheviot hills which form the boundary between Northumberland and Scotland, are of considerable elevation, and of great value for sheep-pasture. In many parts of Scotland are single detached sugar-loaf hills and peaks, greatly resembling Etna and Vesuvius, which from that circumstance, as well as from the substances of which they consist, were undoubtedly volcanoes in some remote age. Of this sort are North Berwick Law in E. Lothian, the Lomonds, and Largo Law in Fife, Dundee Law, Arthur's Seat at Edinburgh, &c. It is also noticeable that these conical hills are all near the sea, as is the case with the above-mentioned volcanoes of Italy, and others at present in a state of eruption.

Rivers. Setting off as before from the Tweed, going up the E. and round by the W. and S. coasts of Scotland, the principal rivers

are these; 1. The Forth, which, proceeding from a number of lakes on the borders of the Highlands, and meeting with the tide above Stirling, gradually opens into the noble estuary called the Firth of Forth, washing the shores of Fife on the N. and of the Lothians on the S. lined on both sides by towns and ports, of which Leith, the port of Edinburgh, is the chief. It communicates with the German ocean, being navigable with perfect safety for the largest vessels for forty miles up from the sea. 2. The Tay issues from a large lake of the same name, becomes navigable for large coasting vessels at Perth, and falls into the sea, six miles below the port of Dundee. 3. The Dee, which forms the harbour of Aberdeen. 4. The Spey, an impetuous stream, principally of service in floating down to the sea, the produce of the forests in the interior of the Highlands. 5. The Ness, which, issuing from the lake of the same name, bears shipping up to Inverness, and is lost in the Murray firth. 6. The N. and W. coasts afford no river of consequence down to the Clyde, which flowing N. W. presents a conveyance for the vast manufacturing and commercial industry of Glasgow, Paisley, and other places in that quarter. 7. The Ayr on the W. and the Nith on the S. coasts furnish commodious tide havens. Besides these natural communications with the sea, Scotland is also traversed by canals of large dimensions: That joining the Clyde and the Forth was already mentioned: but another on an unexampled scale is now carrying on, through a chain of lakes from the Atlantic ocean, in a N. E. direction to the German ocean below Inverness. This canal is to be of such dimensions as to admit ships of 1200 tons, and frigates to pass through, and thereby avoid the dangers to which vessels are exposed in the tedious Navigation round the N. end of the island.

Lakes. From the mountainous nature of the country, Scotland possesses a great variety of lakes, generally situated like those in Switzerland, in deep valleys where the torrents unite, and from which, the mud and gravel with which they were loaded being deposited, issue a number of lively and beautiful streams, hurrying with a rapid course down to the sea. Loch Lomond is the largest and perhaps the most beautiful of the Scotch lakes, it is of a triangular form, 24 miles long, and 6 broad at the base, studded with a multitude of little isles, and inclosed between mountainous and romantic shores. Lochs Tay, Erne, and Ness, are also of considerable extent: in some parts of the last the depth is 150 fathoms, for which reason its surface is never frozen. Narrow arms of the sea running up into the land are also in the Highlands called lochs, such as loch Broom, loch Linny, loch Fyne, &c. noted stations for the herring-fishery.

Mineral productions. Lead iron and coal are those now of the greatest importance in Scotland. The lead mines at Lead-hills in the S. are considered to be the richest in Europe. Iron is found in great abundance, and cast into every possible form in various parts, but particularly at Carron near Stirling. At this vast foundery were first made the short light cannon called thence *Carronades,* first employed by the British, but now adopted by all

the naval powers of the world. The most valuable mineral however, possessed by Scotland is coal, which was worked as far back as the 12th century. The great bed of coal stretches from S. W. to N. E. across the midland counties; but some small veins have been discovered in the most northern quarters of the country. Granite, free-stone, valuable marble, slate, &c. abound in Scotland, and from thence are drawn the stones with which many of the streets of London are paved. Near Dundee is found a kind of stone employed in constructing the great wharfs at Woolwich, and in other public works, having the invaluable property of withstanding the action of sea-water, and the alternate returns of the tide.

Animals. These are the same as in England, unless the small stout horses of Galloway, and the much more diminutive race of the Shetland isles, be peculiar to that country. Vast droves of black cattle are annually furnished by the Highlands for the English markets: the sheep resemble the Welch and South Down breed, and, as well as the beef, furnish excellent food. Deer of different sorts abound in a wild state in the mountains and forests; but no wolf has been seen for above three hundred years past. The whale and the basking shark are no strangers on the coast: but the herring and the salmon are sources of great advantage to the country: of the latter fish the exportation to London, and to foreign parts forms a considerable article of commerce.

Islands round Britain. The principal of these are Wight on the coast of Hampshire, a beautiful and fertile isle, 20 miles long, by 12 broad. Portland is one vast mass of excellent stone, occasionally surrounded by the sea. About 26 miles W. from the extremity of Cornwall by the isles of Scilly or rather Silley, are a cluster of low rocks and shoals inhabited by about 1000 people. On the N. W. corner of Wales is Anglesey, 25 miles long by 18 broad; the chief town Beaumaris. By Tacitus under the Romans, it was called *Mona*, a name by which Cæsar understood the isle of Man. Anglesey is now celebrated for its copper mine: and from Holy Head the most westerly point, is the customary passage over to Dublin. In the midst of the Irish sea, at nearly equal distances from England, Scotland, and Ireland, lies the isle of Man, about 30 miles long from S. to N. and 15 miles broad in the middle. It is in general hilly, producing lead, iron, and copper, cattle, corn, &c. The inhabitants are members of the church of England, under their own bishop, who takes the title of bishop of Sodor and Man, the former in allusion to an episcopal see in antient times in one of the western isles of Scotland. The bishop is under the archbishop of York, but has no seat in the British house of peers. The principal towns are Douglas, Castletown, and Ramsey: the language is a dialect of the antient Celtic, such as spoken in the Highlands of Scotland.

The whole western coast of Scotland is covered with ranges of islands of all sizes, thence called the Western Islands, but in antient times *Hebudæ*, a name ignorantly changed into *Hebrides.* Of these the principal, taking them from N. to S. are *Lewis, Viste,*

Skye, *Mull*, with its appendages *Iona*, once the chief seat of learning and religion of these isles, and of the neighbouring districts of Scotland and Ireland, and *Staffa*, a small island that has greatly excited the curiosity of naturalists, the whole being a vast accumulation of columns, some perpendicular, others inclined in various directions, composed of *basaltes*, a volcanic production that has crystallized in these regular forms. The celebrated *Giant's causey* on the N. coast of Ireland, is of the same nature with *Staffa*. Farther to the S. are *Jura*, *Ila*, *Bute*, and *Arran*.

Orkney and Shetland isles. Separated from the N. of Scotland by the very dangerous strait of Pentland, called Pentland Firth, lie the *Orkney* islands, 26 in number, distributed around the largest, called Mainland, of which the chief town is Kirkwall a sea-port, and formerly a bishop's see. These islands export cattle, hides, salt-fish, tallow, coarse linen, and frequently what corn is not wanted for the inhabitants who are about 20,000. About 30 miles to the N. of the Orkney isles lies the most southern of the Shetland islands, a similar cluster, with a large one in the middle. The only place of note in these islands is Lerwick, on a circular bay or harbour, completely covered by the isle of Brassa, whence it is usually called Brassa sound, a much-frequented rendezvous for the shipping of different nations employed in the whale, herring, and other northern fisheries. The Shetland isles contain about 20,000 inhabitants.

On the coast of France, S. from Dorsetshire, lie three large and a number of small isles, the residue of the antient English dominions in France: these are Alderney, Guernsey, Jersey, &c. Alderney is about 9 miles from Cape La Hogue in Normandy, is 8 miles in circuit, and contains 1000 inhabitants. Guernsey is of a triangular shape, 12 miles from E. to W. and 9 from S. to N. a fruitful island, healthy, and well peopled; the chief town is St. Pierre, having a good harbour, on the E. side of the island. Jersey is a pleasant, fruitful, and well-cultivated island, 12 miles long, and from 5 to 6 broad: the chief town St. Helier, lies on a fine bay on the S. side of the island: the inhabitants are reckoned to be 20,000.

Ireland.

Ireland lies opposite to the W. coast of England, being of an oval figure, the northern extremity in N. lat. 55° 23', and the southern in N. lat. 51° 19'. The extent in longitude is from 5° 36' to 10° 45', both W. from Greenwich; but the length of the island from S. S. W. to N. N. E. is about 310 English miles, and the greatest breadth 160. The superficial area has been computed to be 30,370 square miles, or 19,436,000 acres. Ireland is divided in a peculiar way into four grand districts or provinces, each comprehending a number of inferior districts or counties, as in the following table.

Provinces.	Counties.	Inhabitants	Chief towns.
Ulster	Antrim	160,000	Carrickfergus
	Down	204,000	Downpatrick
	Armagh	120,000	Armagh
	Tyrone	68,700	Omagh
	Londonderry	125,000	Londonderry
	Donegal	140,000	Lifford
	Fermanagh	72,000	Enniskillen
	Cavan	81,500	Cavan
	Monaghan	118,000	Monaghen
Connaught	Leitrim	50,000	Carrick
	Sligo	60,000	Sligo
	Roscommon	86,000	Roscommon
	Mayo	140,000	Castlebar
	Galway	142,000	Galway
Leinster	Louth	57,700	Dundalk
	East Meath	112,000	Trim
	Dublin	200,000	DUBLIN
	Wicklow	50,000	Wicklow
	Wexford	60,000	Wexford
	Kilkenny	100,000	Kilkenny
	Carlow	44,000	Carlow
	Kildare	56,000	Naas
	Queen's county	82,000	Maryburgh
	King's county	74,500	Philipstown
	West Meath	69,000	Mullingar
	Longford	50,000	Longford
Munster	Clare	96,000	Ennis
	Limerick	170,000	Limerick
	Kerry	107,000	Tralee
	Cork	416,000	Cork
	Waterford	110,000	Waterford
	Tipperary	169,000	Clonmel

Towns	Dublin	170,000	Kilkenny	16,000
	Cork	80,000	Dundalk	15,000
	Limerick	50,000	Galway	12,000
	Waterford	35,000	Wexford	9,000
	Belfast	20,000	Kinsale	8,000

According to this table the population of Ireland amounts to about 3,600,000: but an estimate made in 1804 carried the number of inhabitants to 5,500,000. It is evident however, from the numbers belonging to each county and town, that they are the results of rough conjecture and not founded on proper grounds of computation. In the following list of the principal towns of England, Scotland, and Ireland, a comparative statement is given of the population of each.

Towns.		Inhabits.	Towns.		Inhabs.
London, &c.	E.	1,009,546	Greenock	S.	19,042
Dublin	I.	170,000	Exeter	E.	18,896
Edinburgh	S.	102,987	Shrewsbury	E.	18,543
Glasgow	S.	100,749	York	E.	18,217
Manchester	E.	98,573	Yarmouth, Norfolk	E.	17,977
Liverpool	E.	94,376	Stockport	E.	17,545
Birmingham	E.	85,753	Preston	E.	17,065
Cork	I.	80,000	Perth	S.	16,943
Bristol	E.	71,279	Chester	E.	16,140
Leeds	E.	62,534	Kilkenny	I.	16,000
Plymouth and Dock	E.	56,060	Dundalk	I.	15,000
Limerick	I.	50,000	Wolverhampton	E.	14,836
Portsmouth & Portsea	E.	40,567	Wigan	E.	14,060
Norwich	E.	37,256	Dudley	E.	13,925
Sheffield	E.	35,840	Worcester	E.	13,814
Aberdeen	S.	35,370	Ipswich	E.	13,670
Waterford	I.	35,000	Derby	E.	13,043
Nottingham	E.	34,253	Oxford	E.	12,931
Bath	E.	31,496	Colchester	E.	12,544
Paisley	S.	31,179	Carlisle	E.	12,531
Dundee	S.	29,616	Sunderland	E.	12,284
Newcastle up. Tyne	E.	27,587	Galway	I.	12,000
Hull	E.	26,792	Warrington	E.	11,738
Coventry	E.	23,787	Dunfermline	S.	10,568
Leicester	E.	23,146	Falkirk	S.	9,273
Rochester & Chatham	E.	21,722	Wexford	I.	9,000
Belfast	I.	20,000	Inverness	S.	8,875

Climate and soil. Ireland and England being situated at the same distance from the equator, the climate of the two countries is nearly alike, but in Ireland it is more moist than in England, rendering the country fitter for pasturage than for grain. Although Ireland be in general a plain country, yet in some quarters are hills of considerable elevation; Slieve Donard in the county of Down, rising to the height of 3,000 feet. Vast tracts in Ireland are

covered with bogs, some marshy, others clothed with grass, and dry in summer; a third sort consists of peat, furnishing a common article of fuel.

Rivers. 1. The Shannon, which, rising in the N. W. runs S. and W. spreading often into broad lakes, and forming the harbour of Limerick, falls into the Atlantic with an opening 10 miles wide, 50 miles below that town. 2. The Barrow, rising in the heart of the island, flows S. and W. to the sea, below the haven of Waterford. 3. The Liffey is chiefly noticeable as flowing through the centre of Dublin, where, by the help of the tide, it is navigable for merchant ships of moderate size. 4. The Boyne, memorable for the decisive victory gained on its banks by William III. over his father-in-law James II. flows from W. to E. to Drogheda, where it receives ships of burden.

Lakes. In Ireland are several considerable lakes or loughs, such as lough Neagh in the N. 22 miles by 12, lough Erne in the N. W. consists properly of two lakes connected by a narrow channel, inclosing an island on which stands the town of Enniskillen: the length of the two is 30 miles, and the greatest breadth about 10. The most interesting to the eye is the lough of Killarney, in the S. W. corner of the island, surrounded and interspersed with picturesque scenery of rock and wood, of island and mountain.

Minerals. Both iron and copper are found in Ireland, also lead conjoined, as in Scotland, with silver: some years ago, the public attention was excited by the discovery of massives of native gold in a brook in the Wicklow hills, on the S. of Dublin. Coal is found in different quarters, particularly in the N.; but hitherto not wrought to a proper extent, so that Dublin and other towns are chiefly supplied with that fuel from Wales, Cumberland, and Scotland. Marble, freestone, and slate, are common; and the Giant's causey, a prodigious assemblage of basaltic columns, on the N. coast, similar to those composing the island of Staffa on the W. coast of Scotland, has long been celebrated.

Animals. These are generally the same as in England, unless it be true that the viper is unknown in Ireland, which is the only poisonous animal in Britain. Deer of a peculiar kind must have once inhabited Ireland, as may be judged from the horns found buried in the bogs, some of which measure 14 feet from tip to tip. The great wolf dog is now very rare, as their use in hunting the wolf has not been wanted for a century past. This dog resembles the great Dane, and was probably carried by the Danes into Ireland during their invasions of the country.

Islands. These are neither considerable nor many, Cape Cleare, commonly called the S. extremity of Ireland, is in fact the point of a small island near the coast. Valentia, the N. and S. isles of Arran, and Tory island, a well known mark for seamen, lie along the W. coast. Rachlin on the N. coast, is chiefly remarkable for having been noticed in antient geography under the name of *Ricina.*

Religion of the Britannic isles. The protestant reformed religion is by law established in all the British isles, with certain modifica-

tions relating more to the form of church-government and the rites and ceremonies of divine worship, than to the doctrines professed by each communion. In England and Ireland, the system is that peculiarly termed the Anglecian church, or church of England, which at the reformation retained the hierarchy or episcopal form of government, and the use of a public liturgy or common prayer. In Scotland, since the revolution, the presbyterian form has been established, in which the whole body of the clergy are perfectly equal in rank and dignity, and all ecclesiastical matters are administered by a gradation of elective and representative assemblies of pastors and lay-elders. England contains two provinces or archbishopricks, viz. Canterbury, and York. Under Canterbury are the biships of London, Winchester, St. Asaph, Bangor, Bath, and Wells, Bristol, Chichester, St. David, Ely, Exeter, Gloucester, Hereford, Landaff, Lincoln, Litchfield, and Coventry, Norwich, Oxford, Peterborough, Rochester, Salisbury, and Worcester; and under York are the bishops of Durham, Carlisle, and Chester, with the Bishop of Sodor and Man, resident in the isle of Man. Next to the archbishops, the bishops of London, Durham, and Winchester, hold peculiar rank as here named, but all the other prelates take rank according to the date of their consecration. In Ireland arefour archbishops, namely, Armagh, Dublin, Cashel, and Tuam. Under Armagh are the bishops of Clogher, Derry, Down, and Cannor, Dromore, Kilmore, Meath, and Raphoe: under Dublin are Kildare, Leighlin, and Ferns, and Ossory: under Cashel are Waterford, and Lismore, Limerick and Ardfert, Killaloe and Kilfenora, Cork and Ross, and Cloyne: under Tuam are Cloufert, and Kilmacduagh, Killalla and Achonry, and Elphin. Scotland contains 1009 parishes, distributed into 78 presbyteries, and forming 15 provincial synods, viz. 1. Lothian and Tweed-dale; 2. Merse and Tiviotdale; 3. Dumfries; 4. Galloway; 5. Glasgow and Ayr; 6. Perth and Stirling; 7. Fife; 8. Angus and Mearns; 9. Aberdeen; 10. Moray; 11. Ross; 12. Sutherland and Cathness: 13. Argyle; 14. Glenelg; 15. Orkney and Shetland: the whole united under one general assembly of the church held annually in May, at Edinburgh. Those who dissent from the established church in England are very numerous, and subdivided into various classes: in Scotland dissenters are comparatively few in numbers; but in Ireland, nine-tenths of the people are computed to follow modes of religion different from that of the state. Of these, eight-tenths, or four-fifths of the whole population are supposed to profess the Roman Catholic faith; and another ninth to be protestant dissenters, chiefly in the N. where the system of the church of Scotland prevails; so that of the whole people of Ireland, only about one in ten adheres to the established church.

Universities. These in England are two, Oxford, and Cambridge; in Scotland four, St. Andrews, Glasgow, Aberdeen, and Edinburgh. Ireland contains but one university, viz. Dublin.

Government. On the death of queen Elizabeth in 1603, James VI. of Scotland, succeeding in right of blood to the kingdom of England, the two crowns were united: but it was not till the

22nd of July 1706, in the reign of Anne, that the two countries were united in one kingdom, under the name of Great Britain. Ireland continued a separate state, under the crown of Britain, till the 1st of January 1801, when the three states were conjoined into one, styled The United kingdom of Great Britain and Ireland. The British constitution is a hereditary but limited monarchy, balanced by two senates or houses of parliament, the one consisting of hereditary peers created by the king; the other of representatives chosen by the people. From its nature the house of peers or lords is not restricted in numbers, as is the house of commons, which now consists of 658 members, viz. 80 for the counties, and 409 for the cities, boroughs, and universities of England; 12 for the counties, and 12 for the boroughs of Wales; 30 for the counties, and 15 for the cities and boroughs of Scotland; and 100 for the counties, cities, and boroughs of Ireland.

II. Denmark and Norway.

These countries extend from the Elbe at Hamburgh in N. lat. 53° 43', to the North cape in Lapland, in N. lat. 71° 10' or 1047 geographic, equal to 1204 English miles, including 70 for the breadth of the Cattegate, an arm of the German ocean, running in between Denmark and Norway and communicating with the Baltic. Of this long tract Denmark occupies 250 miles, and Norway 884. The breadth of Denmark from W. to E. including the numerous islands, is 150 miles: that of Norway in the southern parts 240, but in the northern parts less than 40 miles. The population of Denmark is estimated to be 1,600,000, and that of Norway at 900,000; in all 2½ millions. Copenhagen the capital of Denmark, a handsome strong town with an excellent harbour, on the E. side of the island of Zealand, contains 90,000 people. Bergen, a sea-port, and the capital of Norway, contains 20,000. Other towns of Norway are Drontheim, once the capital in the N. and Christiana in the S. whence vast quantities of deal, iron, and copper are exported. In countries stretching so far to the N. the climate must be very various. Even in Denmark, the Sound and other straits between the islands are frozen over in winter. In Denmark proper the country is low and flat, and subject to inundations, but the southern parts are very fertile in grain and pasturage. Norway on the other hand, in general covered with rugged mountains, produces very little corn, but some good pastures, and vast forests of fir, pine, and birch. Denmark contains no rivers of note, but Norway abounds in streams or rather torrents of considerable size, which are too rapid to be navigable, but are of great service in floating down to the coast the timber cut down in the mountains, which, in the great chain running N. and S. along the frontiers of Sweden, rise in certain points, to the height of 9000 feet, or nearly 1¾ mile. The southern districts of Denmark produce large and excellent horses and cattle; and at the northern extremity of Norway in Lapland are found numbers of rein-deer, a most useful animal for the inhabitants of that dreary region.

Norway affords also excellent copper and iron for exportation, with silver enough for the Danish mint. Besides the valuable islands of Denmark, viz. Zealand, Funen, &c. and the innumerable isles which line the shores of Norway, to the same crown belongs the great island of Iceland, situated in the Northern ocean, between lat. 63° 30′ and 66° 45′, and between W. long. 16° and 25°, being about 270 geographic, or 320 English miles long from W. to E. and 230 broad from N. to S. The inhabitants are reckoned to be 50,000. The climate of this island is too cold to produce either wood or grain in any useful quantities; although in former times it was much more productive and much better peopled than in these days. The ice from the coast of Greenland is yearly accumulating on the northern shores of Iceland, and will in the progress of time render the country entirely uninhabitable, notwithstanding the violent heat in the bowels of the earth, which indicates itself by Hecla and other volcanoes, boiling springs of prodigious size, and by the vast masses of volcanic matter with which the greater part of the island is covered.

The dominions of the king of Demark profess the Lutheran system of the protestant faith; and the government, ever since the revolution in 1660, has been considered as an absolute monarchy: although the Norwegians retain a considerable share of their original independence.

N. B. Norway having, for many centuries, been subject to the crown, although not united with the kingdom of Denmark, it has been thought right to conjoin them in the same description. The king of Denmark, in the course of last summer, resigned all his claims to the sovereignty of Norway, which was immediately transferred to the crown of Sweden, retaining however its former constitution, laws, and religion. This arrangement, however expedient to be adopted by the court of Denmark, was submitted to by the Norwegians with great reluctance: but left to their own resources, in a time of peculiar calamity, when the attention of Europe was occupied by other important matters, they wisely came to an accommodation with their invading neighbours of Sweden, to which Norway is now politically conjoined.

III. Sweden.

Sweden is situated between 55° 20′ and 70° of N. lat. and between 12° and 29° of E. long. being about 1000 English miles from S. to N. and about 500 in its greatest breadth from W. to E. including the gulf of Bothnia, and Finland on the E. side of that gulf, which, long belonging to the Swedish crown, was at the late peace between Sweden and Russia, ceded to the latter power. Whether this cession is to be definitive, any more than that of Norway by Denmark to Sweden, cannot yet be determined: the whole population has been estimated at 3 millions. Great varieties of climate are experienced in Sweden, and even in the southern districts the winters are tedious and severe. The strait called the Sound, separating Sweden from Denmark, about three miles across

where narrowest, is generally frozen over every winter; and the broad gulf of Bothnia itself is frequently passable by travellers on the ice. This is not altogether owing however to the intense cold, but in a great degree to the freshness of the waters of the Baltic, and the want of tides to agitate them. Sweden is greatly diversified by lofty mountains, broad lakes, and rapid rivers: but the soil, not naturally fertile, is cultivated with such industry as to furnish many of the necessaries of life. The mountainous tracts supply pine and fir timber for exportation: and the mineral productions of Sweden have long been abundant and rich. Gold and silver have been extracted; but the wealth of the country consists chiefly in its mines of copper, lead, and iron. The capital of Sweden is Stockholm, singularly situated on a cluster of rocky islands in a deep channel, by which the waters of the Meler lake are discharged into the Baltic. The town contains 80,000 people; and the harbour is excellent, but of difficult access. Upsal, a celebrated university, from whence the great botanist Linnæus (in Swedish Linné,) dispersed over Europe his stores of natural knowledge, is situated on the N. of Stockholm. On the S. W. coast, at the mouth of a navigable river, lies Gottenburgh, a handsome sea-port, containing 30,000 people, and much frequented by shipping from Britain, and other foreign countries.

To the crown of Sweden belong several islands lying in the Baltic sea, of which the principal is Gothland, 70 miles long, and 24 broad, fertile in corn and sheep-pasture. On the S. shore of the Baltic, between the dominions of Denmark and Prussia, a share of Pomerania, with the capital Stralsund, belongs to Sweden. Lutheranism is the established religion of Sweden; and the constitution since 1789 is, in practice, an absolute monarchy.

IV. Russia.

The vast Russian empire occupies the whole of the northern parts of Europe and Asia, from the limits of Sweden and the Baltic, to the sea which separates Asia from N. America; extending from 30° to 190° of E. long. or about 4500 English miles. Russia in Europe is about 1400 miles from W. to E. and 1700 miles from the Black sea N. to the Frozen ocean. The population of Russia in Europe in 1808, was estimated at 32 millions, and of Russia in Asia, at 9 millions, in all 41 millions, of which, Petersburgh, the modern capital, contains 130,000, and the old capital, Moscow, before its late disasters occasioned by French invasion, contained twice that number. Russia is in general one vast plain, without any hilly tracts deserving of notice; the highest land in the environs of Moscow, where the great rivers have their sources, not being more than 1200 feet above the sea. The greatest river in Russia and in all Europe, is the Volga, which, rising between Moscow and Petersburgh, falls, after a very circuitous course of 1800 miles, into the Caspian sea below Astracan. The Don and the Nieper flow into the Black sea; the Dwina runs N. to

Archangel, a port on the Northern or White sea; and the Duna falls into the Baltic, below the noted port Riga. The largest lakes of Europe are found in Russia: Ladoga being 130 miles long by 70 broad, and Onega 150 long by 30 broad. The last communicates by a river with the first, and the waters of both are discharged into the Baltic by the Neva, on the banks and interjacent islands of which Petersburgh is constructed. From the wide extent of this great country, the vegetables and animals of the warm, the temperate, and the frigid zones, may be expected to prevail in its different districts. The population is also composed of very different races of men. The diminutive Laplanders and Samoiedes, on the N.; the hardy and laborious Russians proper, of the centre; the Cossacks, and other nations of Tartar origin and habits of the S. although all united under one sovereign, still retain many distinguishing marks of their origin, in stature and complexion, in language, customs, and religion. From the white bear of the N to the camel of the S. animals of every European kind are found in Russia. A distinctive feature of Russia, next to the general levelness of its territory, is the prodigious number and extent of its forests. Even on the most frequented road in the empire, that between Moscow and Petersburgh, a distance of 450 miles, the road leads, for one-third of the way, through a continued forest of oak, beech, pine, and fir. The principal articles exported from Russia are, fir-timber, hemp, flax, hides, tallow, honey, &c.

The prevailing religion of Russia is the Greek church, holding in several points, a middle course between the Roman catholic and the protestant creeds. The language of Russia is a branch of the antient Sarmatian, the most extensively spoken of any in Europe, being used besides, with local variations, in Poland, Bohemia, Hungary, Sclavonia, and in certain parts of Turkey. The government of Russia is an absolute monarchy.

V. The Netherlands.

The low flat country extending along the E. shores of the German ocean opposite to England, from the N. frontier of France towards the mouth of the Elbe, was from its nature early known by the name of the *Low Countries*, or *Netherlands*. It belonged for some time to the common sovereign of Austria and Spain, and was then divided into seventeen provinces: but towards the end of the 16th century, the seven northern provinces, having embraced the doctrines of the Reformers, and being driven to insurrection by the tyrannic measures adopted against them by Philip II. of Spain, the husband of Mary of England, threw off their allegiance, and formed themselves into an independent federal republic, under the title of the *Seven United Provinces*. The remaining ten provinces were again brought under subjection to the house of Austria, and so continued until, in the course of the revolutionary war with France, they were overrun, and at the peace finally incorporated with that power. The whole seventeen provinces are now, in consequence of the overthrow of the French empire, once

more united in one common sovereignty under the prince of Orange, the hereditary *stadholder*, or chief magistrate of the Seven United Provinces, and the lineal descendant of the Prince of Orange, by whose patriotic exertions those countries were chiefly rescued from the yoke of Philip II.

The ten Austrian provinces occupied the greatest part of the countries of Flanders and Brabant; and the southern tracts being more elevated above the sea than the northern, have long been celebrated for their fertility in corn and pasture, as well as for the population. The capital, Brussels, is a handsome town, having communication by canals with the sea, and containing 80,000 people. Antwerp, a large town on the E. bank of the river Scheld, there fit to receive the largest ships, was once the principal port and mart in the W. of Europe: and by the union of the whole of the Netherlands under one sovereign, will doubtless be restored to some share of its former commercial importance. Other considerable towns are Ostend a sea-port, Bruges, Ghent, Louvain a celebrated university, Namur and Maestricht, fortresses of great strength, Liege, noted for its cutlery, &c.

The *Seven United Provinces* are generally known by the name of the most considerable among them, namely, Holland, the other six being Friesland, Groningen, Overyssel, Utrecht, Gelderland, and Zealand. The extent of the whole territory, including the islands, is about 150 English miles from N. to S. and 100 from W. to E.: the inhabitants about 2½ millions. But as a considerable portion of the country is occupied by inland seas and lakes, with barren sandy heaths, and marshes, the population of the other parts is much greater in proportion to their extent than that of any other similar tract in Europe. The country being so much intersected and surrounded by water, the climate of Holland is very moist; and in winter, although no part is so far to the northward as the mouth of the Humber in England, yet the cold is so intense that not only the rivers, canals, and stagnated waters, but even the inlets of the sea are locked up by the ice. The Rhine, one of the principal rivers of Europe, terminates its course in Holland: but there receiving the Maes or Meuse, a much inferior stream proceeding from the N. E. parts of France, the latter gives name to the united waters which pass by Rotterdam and the Brill, into the sea. Holland produces very little grain, but abounds in rich pasturage for cows, affording great quantities of butter and cheese, for exportation, as well as for home consumption. The Dutch coasts produce plentifully turbot, plaice, &c.; but the herrings, for curing which the Hollanders have long been famous, were drawn from the coasts of Scotland and England. The towns in Holland differ in general appearance from those of most other countries. The streets are usually broad and straight, having in the middle spacious canals which bear ships up to the merchants' doors. The capital of the province of Holland is Amsterdam, at the bottom of the gulf called the Zuyder or South sea, to distinguish it from the German ocean or North sea; the inhabitants have been computed at 240,000; Rotterdam, the next sea-port of

importance, contains 45,000; Leyden, a celebrated university, 50,000; and the Hague, formerly the seat of the government, and ranked only as a village, contained 36,000 people. The established religion of the United Provinces is, the Calvinistic branch of protestantism, similar to the church of Scotland.

VI. Germany.

By this term we understand a multitude of states of various degrees of extent, population, and importance, occupying the heart of Europe, and extending about 600 English miles from N. to S. from the Baltic to the Alps, and about 500 miles from W. to E. from the Rhine to the frontiers of Poland. This country we call Germany from the *Germania* of the antient Romans; a term descriptive rather of the inhabitants than of their country. *Garman* signified a *warman*, a denomination assumed by the nations of that quarter who came in contact with the Romans, to express the idea they had of their own military talents: but which, misunderstood by their southern antagonists, was converted into the name of a country. Of the tribes antiently inhabiting Germany, one of the most powerful was that of the *Teutones:* and from them came the modern name *Deutschland,* and *Deutsch* for the people. This appellation was corrupted and improperly confined by us to the natives of Holland, whom we call *Dutch*. Being situated between the 46th and 54th degrees of N. latitude, the climate of Germany is in general temperate, although on the shores of the Baltic, and in the vicinity of the Alps the cold be severe: such however, is the temperature of the middle provinces that, besides rich crops of corn and pasture, much wine of valuable qualities is produced. The face of the country is generally level, resembling the eastern parts of England. Germany in its extended sense gives rise to some of the greatest rivers in Europe,—the Danube, flowing from W. to E. by Vienna, falls into the Euxine or Black sea, being navigable for upwards of 1200 miles, and carrying along with it the waters of the Lech, the Inn, the Drave, and many other very considerable streams. The Rhine, running from S. E. to N. W. separates Germany from France; receiving from the former sundry large streams, particularly the Maine, which passes through Frankfort noted for its fairs, and by Hockheim, whence comes the celebrated wine called by us Old Hock. Germany possesses few lakes, but it abounds in salt springs, and in various minerals of great value. The mysterious substance amber, is found in much greater plenty on the Prussian shores of the Baltic, than in any other region of the world.

From the present unsettled state of public affairs in Germany, it would be idle to offer any precise account of the several kingdoms and smaller dominions of which it is composed. It must therefore be sufficient to give the following summary account of the most remarkable divisions of the country.

German Empire. In consequence of the removal of the seat of government from Rome to his new capital Constantinople, by

Constantine the Great, in the year 330, the Roman empire came to be split into two, the Eastern, and the Western. After many vicissitudes, the Western fell into the hands of Charlemagne (a name corrupted from *Carolus Magnus*, or Charles the Great,) who assumed the title of emperor of Germany, and conferred on the heir-apparent of the crown, that of king of the Romans. In the course of time the office of emperor became elective in the hands of nine of the principal chiefs in Germany, of whom the king of Great Britain, as duke of Hanover, was one. For many years past, the successful candidate for the imperial honours was the archduke of Austria, who is also king of Hungary and of Bohemia. In consequence of the irruptions of the French troops in the late war, the antient Germanic constitution was overthrown, and the present emperor, in order to preserve a dignity long possessed by his family, declared himself to be emperor of Austria, and that the title should descend by inheritance to his posterity. There is therefore at this moment no such personage as the emperor of Germany: it is however, rumoured that the title and office will probably be restored, and secured without further election or contest to the chief of the house of Austria.

Austrian dominions. These consist principally of Austria proper, a populous and plentiful country, of which Vienna (in German *Wien*) is the capital. It stands on the south bank of the Danube; there separated by islands into a number of channels, and contains about 260,000 inhabitants. Adjoining to Austria on the east, lie Hungary and Transilvania. Presburg, the capital of the former country, stands on the north side of the Danube, 42 miles below Vienna, containing about 30,000 people. The celebrated wine of Tokay, grows in the neighbourhood of a town of that name in Hungary. A great part of its excellence is owing to the very particular care bestowed on the selection and maturity of the grape employed in the manufacture of the liquor. Prague, the capital of Bohemia, in the centre of Germany, on the Moldaw, contains 80,000 inhabitants. The Austrian dominions are singularly rich in minerals. Silver, some gold, and tin, lead, iron, sulphur, coal, and salt, are found in various quarters: the mines of quicksilver in Carniola have produced above 130 tons in one year.

Prussia. This country was erected into a kingdom in 1707. Before the annexation of a part of Poland the population was counted at 5 millions; but now at 8 millions. The capital, Berlin, an inland town on the Spree, is remarkably well built. Koningsberg, the chief town of Prussia proper, (for Berlin is in Brandenburg,) Dantzick at the mouth of the Vistula, Stettin on the Oder, and Elbing, are the principal ports. The northern parts of the Prussian dominions contain many lakes, marshes, and forests, and the country round the metropolis presents little but barren sandy plains: the southern provinces however, are fertile and healthy. The most remarkable production of Prussia is amber, found on the shores of the Baltic, and in some places at a good depth under ground; and producing a revenue of four or five thousand pounds.

This substance which, as it possesses many of the properties of resins, is supposed to be of a vegetable origin, and which, after the Arabians we call *amber*, was by the antient Greeks called *electron*. From its property of giving light, and attracting certain substances when rubbed and heated, is derived the general term *electricity*, now applied to similar powers in other substances, by whatever means those powers are excited.

Bavaria, lying chiefly between the Danube and the Alps, is in general an extended plain, abundant in corn and pasture, furnishing also silver, copper, and lead: but its great mineral treasures are the salt-mines. The capital, Munich, on the W. bank of the Iser, which runs N. E. to the Danube, is a handsome town of above 30,000 inhabitants. In the course of the late continental revolutions, the duchy and electorate of Bavaria assumed the rank of a kingdom.

Saxony, a fertile, well-cultivated, and populous country, on both sides of the Elbe, produces grain, hops, flax, hemp, tobacco, and some good wine, with silver, tin, copper, lead, and coals. In former times by Saxony was understood a much more extended tract of country, reaching down to the German ocean between Holland and Denmark. Preferring to the sober cultivation of the soil the adventures of foreign expeditions, the Saxons invaded Britain, France, and other countries accessible by sea. So successful were these invaders in Britain as to divide the southern parts into seven kingdoms, hence called by a Greek phrase the *heptarchy* or seven governments. Of these small states some memorial still remains in the names of the counties of Essex (East Saxons,) Sussex (South Saxons), and Middlesex (Middle Saxons:) and from the *Angles* one of their tribes, were gradually formed the Latin term *Anglia*, and the vernacular terms *Angle-land* and *England*, still accurately translated and preserved in the French, *Angleterre*. The Welch and the Highlanders of Scotland, the genuine descendants and representatives of the Britons, the original inhabitants of this island, still designate the Lowlanders of England and Scotland by the name of *Sassenah*, that is to say, *Saxons*. The same term is employed by the Irish, whose language is a dialect of the antient *Celtic*, formerly the common language of these islands, of France, and of other parts of the continent.

Saxony, from a duchy and electorate, was, some years ago, advanced to the rank of a kingdom, receiving at the same time a great accession of territory out of the spoliation of the antient kingdom of Poland. The capital of Saxony is Dresden, a large and handsome town, through which runs the Elbe, over which is a bridge nearly 2000 feet long. The inhabitants some years ago exceeded 120,000, and upwards of 100,000 were formerly reckoned in Leipsic, celebrated for its university and its fairs. Wittemburg on the Elbe, is noted for the abode and the tomb of *Martin Luther*, the inflexible opposer of the assumptions of the court of Rome, and the founder of the Reformation in religion. In Saxony the German language is spoken and written with greater purity than in any other district of that great country.

Hanover. James VI. son of the ill-fated Mary Stuart of Scotland, who fell a victim rather to the personal than to the political jealousy of her cousin queen Elizabeth, succeeded to the crown of England on the death of the latter in 1603. His daughter Sophia had, by her husband the elector Palatine of the Rhine, a daughter of the same name, who married Ernest Augustus, duke and the first elector of Hanover. Upon the death of queen Anne in 1714, the last daughter of James II. without surviving issue, although she had had, by her husband George Prince of Denmark, no fewer than six sons and seven daughters, the crown of these kingdoms was by parliament conferred on George duke of Brunswick-Lunenburg, and elector of Hanover, in right of his mother Sophia as the grand-daughter of James I. of Great Britain: thus confirming in the house of Stuart, the imperial crown of Britain and Ireland. Since that period, now a century ago, the connection between Hanover and this country has been most intimate, at the same time that, although both states are subject to the same sovereign, no alliance or league for their common interests really does exist between the two countries. Nay, so far is this from being the case, that in the commencement of hostilities upon the continent, the sovereign of Hanover was at peace with France, at the very time when the sovereign of Britain was in open active war with the same country. Towards the close of 1814 the electorate of Hanover was converted into a kingdom in the person of our present venerable sovereign George III. Upon this occasion some additions were made to the territory of Hanover, which formerly contained about 8300 square miles, and a population of 850,000. Hanover, the capital, a handsome fortified town on the river Leina, contains about 25,000 people. Gottingen is a celebrated seat of learning, founded by George II. of Britain. The country of Hanover is in general a sandy plain: but in the south are the Hartz hills, containing silver mines that have been wrought from the year 968.

Brunswick contains about 1500 square miles, and 170,000 people, of which the capital, large but ill-built, possesses 20,000. The country in appearance and productions resembles Hanover, within which it is in a manner inclosed. The house of Brunswick of great antiquity, is divided into several branches, of which that of Lunenburg established in Hanover, is now seated on the British throne. The princess of Wales is a daughter of the late duke of Brunswick, by a sister of his present majesty, and consequently the cousin-german of her husband the prince regent.

Wirtemburg. This duchy now become a kingdom, (of which the princess royal of Britain is queen) contained before its accession of territory 600,000 people. The country is much diversified with mountain and plain, and sufficiently productive in grain, with some wine; it furnishes also silver, copper, lead, iron, sulphur, coal, and salt. Stutgard is the capital, and at Tubingen is an antient university.

Hesse is an extensive country, in general hilly, but with many

fruitful valleys, and possess many valuable minerals: the capital is Cassel.

Mecklenburg is divided into two duchies, Strelitz and Schwerin. of the former is the present queen of Britain. The country of both is sandy, and much interrupted by lakes, marshes, and heaths, although Schwerin contains many rich pastures. The chief productions are oats and rye, flax, hemp, cattle, wool, and some timber. Of the towns, Rostock is the most noticeable on account of its university.

Saltzburg, a very romantic tract on the northern skirts of the Alps, consists chiefly of lofty mountains and deep vallies, watered by torrents and lakes. It possesses much forest and pasture, and is very rich in minerals, such as gold, silver, copper, and lead: but its chief wealth of this sort is the salt found in the bowels of the mountains.

The remaining smaller states of Germany cannot conveniently be noticed in this place: but the reader will naturally expect some account of those places in Germany designated under the name of the *Hanse Towns*. By this we understand a confederacy of several sea-ports which conducted the greatest part of the commerce of Europe. This association in the course of time comprehended the whole western coast of Europe, and even ports in the Mediterranean; the design of it being the general defence of traders against the pirates of the north. On this account it was encouraged and promoted by the governments of the different states in which the towns lay; so that in the year 1200 no fewer than 72 towns belonged to the Hanseatic union, and so powerful were they, that their ships were often hired by different princes, to assist them against their enemies. At length however, by the 16th century, the power of the associated towns gave umbrage to several princes, who commanded the towns within their bounds to withdraw from the association. This immediately struck off all but those within the territory of Germany, which placed themselves under the protection of the emperor. In this state the Hanseatic union continued for some time, but at length the whole was reduced to the sea-ports of Bremen and Hamburgh, on the German ocean, and Lubec and Dantzick on the Baltic; each of which towns afterwards carried on a separate trade upon its own account.

VII. Poland.

This large and important division of Europe has long ceased to be an independent state. Formerly it extended from the Prussian frontier eastward 600 miles, and from the Austrian dominions northward above 400: the inhabitants were then estimated at 12 millions. Warsaw, the capital, on the great river Vistula, (*Weichsel,*) which falls into the Baltic below Dantzick, contained 65,000, and Cracow once the capital, about 25,000 people. Poland is one vast plain: but the Carpathian (Krapak) mountains sepa-

rating it from Hungary on the south are very lofty. Great part of the country is covered with forests of fir, from which are drawn by the ports of Konningsburg and Memel great supplies of timber, by the western and southern states of Europe. Grain is also raised and exported from Poland in very considerable quantities, as also flax and hemp. The salt mines are confessedly the most remarkable works of that kind any where to be seen. The forests swarm with bees, and of the honey is made the liquor called in Polish *moid*, from which we have derived our term *mead*.

The whole states, included under the name of Poland, formerly composed a republic, with an elective king at its head, the sovereign power being however vested in the senate and the assemblies of the nobles. The king was chosen by the counsellors of state, spiritual and temporal, and by representatives from the principal cities of the kingdom. In proportion as the nobles were zealous in the maintenance of their own privileges against the power of the king, with so much the greater severity did they press upon the peasantry and laborious part of the community, who possessed not even the shadow of freedom, personal or political. The last king of Poland, Stanislaus Augustus, (who, not many years ago, resided for a considerable time in England, under his own title as count Poniatousky,) with a spirit and purposes worthy of better times, projected, with the approbation of the state, many admirable reforms in the government. Accordingly a new constitution was adopted by the nation at large, by which the crown was to become hereditary, the king himself voluntarily and magnanimously renouncing all claim to it for any branch of his own family. The legislative authority was to be lodged, where alone it can legitimately be lodged, in senates composed of representatives, elected by the free and unbiassed voice of those who were to be governed. With such a form of government, and the natural advantages of its soil and its situation respecting the surrounding states, Poland must speedily have attained that degree of importance in Europe to which, from its internal political dissentions, it had long been a stranger. This prospect could not be gratifying to the neighbouring sovereigns of Russia, Prussia, and Austria. Pretences were discovered for interfering in the affairs of Poland, the national armies were overpowered, the ill-fated Stanislaus carried off into a foreign land, resigned his crown in 1795, and the kingdom of Poland, rent into three portions, became the reward of its unprincipled plunderers. To adore, but not to scrutinise, the dispensations of Providence is the duty of man: nevertheless, it cannot fail to strike the observer, that the sovereigns of Russia, Prussia, and Austria, the immediate successors of the destroyers of Poland, have been the most severely afflicted by the scourge of French domination and spoliation.

VIII. Switzerland.

Although this portion of Europe has long been separated, in a political sense, from all connection with the Germanic empire,

still, from its local position, the language, the manners and habits of the inhabitants, their institutions, religious, and municipal, it bears a more striking resemblance to Germany, than to either France or Italy, by which, on the W. and S. it is bounded. Driven to distraction by the tyranny and cruelty of the governors placed over them by the house of Austria, on the 6th of January, 1308, a number of chiefs of the mountainous districts of Switzerland, instigated principally by the renowned patriot *William Tell of Altorff*, entered into an association for their mutual support, and in the course of a small number of years the independence of the whole country on every foreign power was formally acknowledged.

Before the country was overpowered by the intrigues rather than by the arms of France, Switzerland was distributed into the following 13 cantons or districts, viz. *Zurich*, *Bern*, *Lucern*, *Uri*, *Schweitz*, which give a name to the whole confederacy which was then projected, *Underwald*, *Zug*, *Glaris*, *Basil*, or *Bale*, *Friburg*, *Soleure*, *Schaffhausen* and *Apenzel*. To these were added, some years ago, the new cantons of *Vaud*, *St. Gall*, *Argow*, *the Grisons*, *the Tesino*, and *Turgaw*; new denominations for districts long ago, either parts of Switzerland or closely united in alliance with it. The union of these states or cantons constitutes the Helvetic confederacy, so called from Helvetia, the antient name of the whole country. Each canton is independent with respect to its internal administration; but all matters concerning the whole confederated body are regulated by a *diet* or general assembly of deputies from the several states. The Roman catholic and the Calvinistic-protestant professions of religion equally divide the cantons: in some of them both are equally followed.

Switzerland is noted for its romantic and picturesque scenery, comprising every thing striking or beautiful, of mountain and valley, lake and river. From its elevated central situation it gives rise to some of the principal rivers of Europe. The Rhone runs W. through France, to the Mediterranean; the Rhine, N. through Germany and Holland, to the German ocean, the Inn, a principal branch of the Danube, (which itself rises on the borders of Switzerland,) flows E. to the Black sea, the Tesino, brings nearly an equal stream to the Po, which, after watering northern Italy, is lost in the gulf of Venice. Of the mountains, many clothed with perpetual snow, nearly equal *Mont Blanc* in height. The lakes are numerous, extensive, and beautiful. The lake of Geneva is in length nearly 60 English miles; its greatest breadth 14: the depth in some places 170 fathoms, or 340 yards. The sloping country on its northern banks, called the *Pays de Vaud*, produces abundance of pleasant wine, and the western parts of the country, which are the least mountainous, are equally fertile in grain and pasture, well cultivated, and well peopled. The population of the whole country has been reckoned at a million and a half. The principal towns in the order of their inhabitancy are, Basil containing 14,000, Bern, Zurich, Lausanna, Friburg, &c.

Geneva is seated on both sides of the Rhone, at the place where it issues from the lake, well built, well fortified, full of people of

enterprize and industry. The territory of this little republic contains a few parishes round the town: the inhabitants profess the protestant religion as established by the great reformer Calvin, who, although a native of the N. of France, found Geneva the most suitable station for the dissemination of his opinions. To Geneva also resorted many of the first reformers of our own country, by whom not only the doctrines of Calvin, but the republican form of church-government adopted by him, was introduced as at this day in Scotland. The same doctrines, although administered under the episcopal form, were, and still are professed in England. Attempts it is true have of late been made, by men of great ability, to shew the articles of religion adopted by the church of England, not to be strictly Calvinistic: the arguments however, employed on this occasion have not been generally convincing, and seem rather to evince what is wished the articles were, than what they really are. Geneva is closely allied, but not united with the Swiss cantons.

IX. France.

France, now retired within the limits she possessed before the awful revolutionary explosion, still extends from N. to S. 600 English miles, and from W. to E. in the greatest breadth 560, and at a medium about 300 miles. The northern frontier at Dunkirk lying in N. lat. 51° 2′, about even with the most southern parts of Britain, and the southern frontier at the Pyrenees lying in lat. 42° 20′, where Spain begins. France occupies the central climates of the globe. The northern provinces abound in corn, the middle in corn and wine, and the southern in corn, wine, and oil. With the exception of the districts bordering on the mountains of the Vosges, the Jura, the Alps, and the Pyrenees, and the interior regions of Avergne, France is in general one vast plain. The climate, as might be expected from the position of the country, is equally exempted from the severe cold of the northern, and from the oppressive heat of the southern parts of Europe; and the soil under the improved system of agriculture, never overlooked by the state, even during the very worst times of the revolution, produces abundance of excellent food for man and beast, not only for internal consumption, but for exportation to foreign lands. The effects of the introduction of French grain and other necessary articles of subsistence, on the markets in London and other parts of this country, are too obvious to require specification. The wines of the hot regions of Spain and Portugal may possess a greater proportion of strength and of inebriating qualities: but for elegant fragrance and exhilarating powers, the superiority is confessedly granted to the productions of the vineyards of Burgundy, of Champagne, of the environs of Bordeaux, (called by us *claret*,) of the banks of the Rhone, and various other quarters of France. Much of the excellence of these liquors however must be placed to the account of the intelligence and attention with which the vine is cultivated, and the wine manufactured. The

same remark is applicable to the oil procured from the olive in Provence, and other parts on the shores of the Mediterranean. In the middle districts of the kingdom a very agreeable oil is expressed from the walnut. France contains many forests of great extent, not only for timber but for common fuel. These however, have severely suffered by the disorders of the revolution; and many mines of coal are now opened in different quarters for firing, but particularly for the use of the great and increasing iron manufactories.

France is plentifully watered and commodiously intersected by navigable rivers. The Seine from the heart of Burgundy, meeting with the Marne a few miles above Paris, flows through the centre of that capital, and passing by Rouen, the Manchester of France, falls into the British channel at Havre de Grace: its course is about 250 miles. The Loire, rising in the south runs in general N. W. and after a course of 500 miles by Nevers, Orleans, and Tours, discharges its waters into the bay of Biscay below Nantes. The Garonne flows from the Pyrenees N. W. by Toulouse, forms the noble harbour of Bourdeaux, and opens by a broad channel called the Gironde into the bay of Biscay. The Rhone soon after it quits the lake of Geneva enters France, runs with a rapid stream S. W. to Lyons, noted for its silks, where it receives the gentle Saone, and then pursues its course with speed due S. by Vienne, Orange, Avignon, and Arles, to the Mediterranean. The Rhine separates France from Germany on the N. E.; and the Moselle, the Maese (Meuse,) the Scheld (Escaut) have all their springs in France.

Prior to the revolution in 1789, France was computed to contain no fewer than 24 millions of people, giving upon average 170 persons on every square mile: the average of England proper is only 146. By the occupation of Flanders and other districts on the N. and E. the French empire contained upwards of 35 millions: but the present kingdom is restricted within its antient limits. Paris, the capital, is of a circular compact form, divided equally by the Seine, which, in the heart of the town, forms several considerable islands crowded with habitations. On the largest of these islands, still containing the cathedral *Notre Dame* (Our Lady's church) and the antique palace of the kings, was situated *Lutecia* a city of the Parisians, in the time of Julius Cæsar, from whom the present town obtained its name. Paris consisting in general of narrow streets of lofty stone buildings, frequently interrupted by edifices of great magnificence, presents a striking contrast to the simple but commodious habitations of London: so that although these two capitals are not three hundred miles asunder, they afford but very few points in which they can be fairly compared together. Before the revolution Paris was supposed to contain 650,000 people, or 100,000 fewer than London. During the disorders of the country the population was very fluctuating: and in 1803 the inhabitants were found to be only 547,756. Lyons was formerly supposed to contain 115,000 people; Marseilles and Bordeaux 80,000; Lille, Strasburg, Nantes, Rouen,

Toulouse, Montpellier and Nimes, from 60 to 30 thousand. But these numbers, from the state of the country for these 25 years past, must be very uncertain: nor can much confidence be placed in some late statements, in which the population of the above and other principal towns seems to be very extravagant, and indicating what it ought to be, rather than what it really can at present be. The horrible waste of human beings, in the wars of republican (or more correctly of revolutionary) and imperial France, can be repaired only by lasting peace abroad, and tranquillity, industry, and good order at home. The acknowledged prudence and beneficence of Lewis XVIII. matured by long experience in the school of adversity, and assisted by the exertions of men of the first talents, without distinction of parties;—these advantages offer fair to render France, in the course of a few years, a prosperous and a happy country. All privileges and distinctions between men born in different ranks of life, are now entirely done away. The government is vested in a king, a house of peers, and a house of deputies from the towns and districts. In the constitution of their house of peers however, the French conceive they have an advantage over us, in this particular, that with them, not every man born a peer, but only a certain number elected out of the great body of the peerage, is entitled to sit in the house, for a certain time.

The established religion of old France was the Roman catholic, and no other could be publicly exercised or professed. Protestants of the Calvinistic persuasion and form of government were nevertheless very numerous in the western provinces towards Rochelle, and in the southern towards Nimes. Lutheranism, it is true, was openly followed in Strasburgh and other parts of Alsace upon the Rhine, having been the established system secured to that country by treaty, when it became a part of France. The protestants of France were taken under the special protection of the benevolent but ill-fated Lewis XVI. who uniformly resisted every attempt on the part of their neighbours, men of more zeal than understanding, to molest them in the exercise of their worship. By the constitutional act recalling the antient royal family, the most perfect freedom and equality, in every civil right and privilege, are declared and secured to all professing Christians, Roman catholics, Lutherans, Calvinists, or by whatever other title they may be discriminated. By this system the clergy, the ministers of religion of all persuasions, are maintained by regular salaries from the national purse, and consequently all jealousy and heart-burnings, not to say dissensions and hostility, are completely extinguished; and Frenchmen of all persuasions, look up with equal confidence for encouragement and protection to a government, in whose eyes all are equally entitled to support.

Prior to the revolution, France, like our own country, was distributed into a number of portions called in general provinces, of very unequal extent and population. When royalty was overthrown one of the great changes introduced was, to divide the country on quite a different plan. It was accordingly laid out in a number of

portions much smaller, and nearly equal extent, named generally from some river by which it was watered, or from some mountain, tract of sea-coast, or other natural feature of the country. These divisions were styled *departments*, and their internal portions *districts*. Thus the country lying round Paris was originally called, by a very singular name, the province of *the Isle of France*. This extensive tract was thrown into the following departments, each distinguished by the rivers running through it, and having its own capital town: viz. 1. the department of the Seine, chief town, Paris; 2. of the Seine and Oise, Versailles; 3. of the Oise, Beauvais; 4. of the Aisne, Laon; 5. of the Seine and Marne, Melun. In the same way the country nearest to England was called the department of the Strait of Calais, (Dover) of which Arras became the chief town. The old provinces were in number 37, which were divided into 85 departments; each having its own bishop for the affairs of the Roman catholic church, and its prefect for the civil administration. This new distribution is confirmed by the present constitution of the kingdom.

X. Portugal.

This kingdom is a portion of the great peninsula of Spain, by which it is bounded on the N. and E. but on the W. and S. it is washed by the Atlantic ocean. Portugal lies between the parallels of 37° and 42° N. lat. being in length from N. to S. 350 English miles; but the breadth from W. to E. is in some places 140, and in others only 70 miles. The number of people in the country has been vaguely computed at 2¼ millions, giving only about 60 persons for each square mile, a very low average for a country blessed with so many advantages in soil, climate, and local situation for extensive commerce. Of this melancholy fact the causes will therefore be looked for in some radical defects in the civil, but above all in the ecclesiastical establishments and institutions, by which Portugal is distinguished from all other European countries, old Spain itself not excepted. Lisbon the capital, admirably situated on very uneven ground, on the N. W. bank of the Tagus, there spreading into a bay 5 or 6 miles across, but afterwards contracting at its entrance into the sea, is supposed to contain 200,000 people. The town owes its principal improvements to the dreadful disasters occasioned by the memorable earthquakes of the year 1755, the effects of which were sensibly felt even in the remote parts of Scotland. The river forms a station for shipping of every size, at once capacious, safe, and greatly frequented. Oporto, whence we draw our *port* wine *(vino de Oporto,)* on the N. bank of the river Douro, about 5 miles up from the sea, contains 30,000 people. Another port much resorted to for salt and fruits, to the S. of Lisbon, is Setuval, the antient Cetobriga, is by the peculiar genius of our seamen for the perversion of names, commonly called St. Ubes.

The climate of Portugal is warm, and were the land properly cultivated for corn, would be generally healthy. The air of Lisbon

and of the hills between the town and the sea, has long been recommended for the restoration of comsumptive and gouty patients from our own and other colder countries. The Tagus has long been celebrated among the rivers of Europe for its golden sands; and in the time of the Romans, mines of gold and silver were wrought within the limits of Portugal. Lead, tin, iron, and some coals are still found. Neither the horses nor the mules of Portugal are equal to those of Spain; and the great friend of human kind the cow is rare, from the negligence rather than the inability of the natives to provide her proper food. So much attention is bestowed on the cultivation of the vine, to supply Port and Lisbon wines to the northern states of Europe, and above all England, with these commodities, that the raising of corn has been so much neglected that importation is continually necessary. By this system the great proprietors of the vineyards and the merchants are rich, while the great body of the labouring classes are often in danger of famine. When apprehensions were entertained, some years ago, that Portugal would fall into the power of France or Spain, the exportation to England of wine from Oporto was not confined, as it ought to have been, to the best sorts, but extended even to the common small beverage of the people. This poor liquor called in the country *vino do ramo*, (wine of the branch or bush, because the public-houses where it is sold are known by a bush hung up at the door; from which practice we have our own old proverb that *good wine needs no bush*, for the toper requires no sign to tell him where he can have good liquor,) transported to England, was soon converted into genuine strong port of the very best quality. The Roman catholic religion alone is suffered in the Portuguese dominions, with a rigid severity that excites the smile of even the Spaniards themselves: the government is an absolute unlimited monarchy.

Azores. These islands, often but improperly called *the Western isles*, which are subject to Portugal, lie in the midst of the Atlantic ocean, about 16° of longitude, or 950 geographic miles due W. from the mouth of the Tagus, and double that distance E. from the coast of Virginia in N. America. St. Michael's is the largest of these islands, being 40 miles long by 12 of mean breadth. In Pico is a volcano rising 7800 feet above the sea. Tercera, though not the largest island, is the principal, and often gives the name of the Terceras to the whole group. The productions are timber, wheat, wine, and fruit.

XI. Spain.

The great Iberian or Spanish peninsula including Portugal is most advantageously situated in the S. W. corner of Europe, between the Atlantic on the N. and W. and the Mediterranean on the S. and E. and commanding by the narrow strait of Gibraltar, only 9 miles broad in the middle, the sole communication between those seas. The position of this noble country for maritime commerce with every quarter of the globe is the most commodious on

the globe. The most southern point at Tarifa on the strait of Gibraltar lies in N. lat. 36° 2', and the most northern on the bay of Biscay in lat. 43° 48'. This is the point of Estaca in Gallicia, and not the neighbouring cape Ortegal, which has hitherto been erroneously believed the N. extremity of Spain. The extent from S. to N. is therefore nearly 540 English miles. The greatest extent of Spain from W. to E. is from cape Finisterre in W. long. 9° 13' to cape Creux the eastern extremity of the Pyrenees in E. long. 3° 16' is about 640 English miles: but the medium breadth of the whole peninsula is about 470 miles. The population of Spain was never well ascertained, but conjectured to be from 11 to 12 millions, a number very disproportioned to its extent: but the fact is that many districts are incumbered with broad and lofty ranges of mountains; and even in the plains, rivers, streams, and springs, are so rare, that the moisture necessary for raising the fruits of the earth (especially by the too general destruction of the forests) cannot be obtained. Where water however can be procured in the valleys, no country can be more fertile. The banks of the Ebro and some other rivers, the maritime parts and plains of Catalonia, Valencia, Murcia, and many other interior tracts even in the mountains of Navarre and Biscay, present scenes of rich fertility, active industry, and multiplied population, of which even in Britain we can form no adequate idea. Such, at least, was the case prior to the unprovoked, unprincipled, and atrocious invasion of Spain by France: and as far as may be probably apprehended from the incomprehensible conduct of the sovereign now restored, for whose sake greater sacrifices were made by the Spanish nation, than ever were made for any prince by any people; many years must elapse before the country can be brought back to its former state. Spain by various causes had fallen greatly behind other states of Europe, in many essential points: for these last 40 years however, many enterprises of great public utility, in agriculture, manufactures, commerce, the arts and sciences, were begun and carrying on with some spirit: but the late horrible warfare in the country threw all these projects into confusion.

Madrid, although a large, well-built, and populous city, does not come up to the notion of the capital of so great a country. The inhabitants are reckoned about 160,000. It stands in the midst of an open but elevated plain on the E. bank of the Manzanares, partaking more of the nature of a mountain torrent than of a permanent river. The palace, a noble but massy quadrangle of modern architecture, commands a wide prospect over the river and adjoining country. Toledo, Salamanca, Saragossa, Grenada, and Seville, are the most noticeable inland towns. Barcelona, large and handsome, is a well-frequented port of commerce in Catalonia, containing about 90,000 people. Tarragona, Tortosa, and Valencia, are all considerable trading towns on the Mediterranean. Great quantities of strong-bodied wine are exported from Alicant on the same sea, of which many a hogshead of *port* and *claret* are afterwards fabricated, chiefly for the English and Dutch markets. Carthagena, a very antient town in the bottom of a small

circular bay, well inclosed by the land, is the chief station of the Spanish navy in the Mediterranean. Malaga on the S. coast is a port of much commerce, chiefly for its rich wines and fruit. Grenada, Cordova, and Seville, large and full of people, preserve many admirable memorials of the architectural skill and magnificence of the Moorish or Saracen princes; to whom, till within little more than three centuries that finest region of Spain was subject. Cadiz, the grand resort of all trading nations, is singularly seated on the outer extremity of a narrow sandy point running out from the island of Leon, and forming a very safe and spacious bay and harbour. Confined by the sea, which has already much encroached on it; the town contains in general only very narrow streets of lofty houses of white stone. It is fortified on the neck of land by which it can alone be approached. The inhabitants are estimated at 70,000. In the neighbourhood upon the continent grows our favourite Sherry wine. It is produced near Xeres, a word pronounced by the Spaniards Heres, and by other nations corrupted into Sheres, as in our name for the wine. In noticing the towns of Spain, Gibraltar must be included, although ever since the treaty of peace of Utrecht, now above a century ago, it has belonged to the crown of Great Britain. From the continent runs out a long narrow low neck of sand for a mile and a half to the rock of Gibraltar, which springs suddenly up to a great height, utterly inaccessible. The mountain or rock stretches still south for 3 miles more to a head-land called Europa point, being the E. boundary of the strait, corresponding to the point and fortress of Ceuta, on the African coast, but belonging to Spain, about 16 miles off. The mountain is quite precipitous on the E. side over the Mediterranean; but the western slope is more gradual, along between which lies the town of Gibraltar, covered by strong fortifications towards the sea, and possessing two long moles for the defence of shipping. The approach to the place by land is naturally difficult from the number of batteries that can play upon it from below, as well as from others cut out of the solid rock above, but because the greater part of the neck of sand can be laid under water at the pleasure of the troops within the place. The bay on the W. side of the town is about 5 miles over to Algeziras in Spain: the water is extremely deep near the fortress; but ships are there often exposed to very violent gales of wind. The persevering gallantry of the garrison of Gibraltar under the heroic Elliot in 1782, against the united genius and efforts of France and Spain, will ever occupy a distinguished place in the military annals of the British empire.

Spain has long been celebrated for its fleeces, much of the excellence of which is with reason attributed to the scanty dry pasture on which the sheep are obliged to feed, so that the animals are in continual motion and consequently kept in good health. By the antient laws of the country, a vast broad space of ground is left in a manner uncultivated over the plains in the centre of the kingdom, for the accommodation of the flocks in their regular progress from the mountainous tracts of Old Castile, Navarre, and

Aragon where they pass the summer, to the more sheltered and fertile plains of Estramadura, where they remain during the winter; again in spring to return north to the summer pastures in the mountains.

The face of Spain is divided in a peculiar manner by ranges of mountains, generally rugged and lofty, running nearly to one another from W. to E. The most elevated of all are the Pyrenees, forming the boundary with France: but the range is continued westward along the coast of the bay of Biscay quite to the extremity of the country at cape Finisterre, properly so called as *Finis terræ*, the Land's-end. Another great belt of high land separates New Castile from Andalusia, called the Sierra Morena, antiently Mons Marius. The term *sierra* (a saw,) is commonly applied in Spain to the teeth-like appearance of the heights and depressions composing the ridge of a high range of rocky mountains. According to the direction of these ranges the great rivers of the country open their way to the sea. The Ebro runs for 300 miles from the mountains of Biscay, in a course E. S. E. by Saragossa and Tortosa to the Mediterranean: but the Duero, called also Douro, when it enters Portugal, falls after a long westward run, into the Atlantic, below Oporto. The Tagus, (in Spanish Tajo, and pronounced Taho,) the largest river in the Peninsula, runs westward from the heart of the country for above 400 miles, by the royal seat of Aranjuez, Toledo, Talavera, memorable for the sanguinary conflict between our troops in conjunction with those of Spain and Portugal, and the French, Alcantura, to Lisbon. The Guadiana and Guadalquiver more to the southward, follow a similar direction, and pour their waters into the ocean.

Spanish islands. These lie in the Mediterranean. Iviza the nearest being 50 nautical miles from the coast of Spain. This with the small island Fomentura are the *Pithyusæ* isles of the antients. Iviza was called *Ebusus*, as its name still shows, which is notwithstanding often printed and pronounced *Ivica.* Farther out to the N. E. lie the greater and less Balearic islands, hence still called Majorca (in Spanish Mallorca,) and Minorca, which last a pleasant and fruitful island, noted for the excellent harbour of Port Mahon, the Portus Magonis of antiquity, has for a course of years been changing from the power of Spain to that of England.

XII. Italy.

The northern parts of this celebrated and most interesting country are bounded by the lofty ranges of the Alps, from the Mediterranean on the S. E. corner of France, round by Switzerland and Germany to the bottom of the gulf of Venice. On every other part it is inclosed by the sea. It consists principally of a long projecting tract of country, running in a S. E. direction, from the Alps to its southern extremity on a stretch of 750 English miles. The breadths however are very different: for the great plain of Lombardy on the north extends for above 250 miles, while in other

parts as in Tuscany it is 100, in the Popes dominions 130, and near Naples about 70. The population of the whole country has been reckoned at 11 or 12 millions. The northern parts contained the king of Sardinia's continental dominions, the republic of Genoa, the duchies of Milan and Mantua, Parma, Modena, the districts of Bologna and Ferrara which belonged to the Pope, and the Venetian states. The centre portion of Italy comprehended the republic of Lucca, the Tuscan territory, and the remaining of the papal dominions. The southern part was wholly in the hands of the king of Naples, otherwise called the king of the two Sicilies. Such however have been the changes introduced into this fine country by French invasion, that it is impossible at this moment to point out, with any chance of accuracy, its political situation. The king of Sardinia has however been restored to his capital, Turin, and the Pope has been reinstated in Rome; but a great, and that the most productive portion of his dominions, are still, under various pretexts, withheld from him. The throne of Naples is occupied by a brother-in-law of the late emperor of France, while the old sovereign is confined to the island of Sicily.

From the beginning of the Alps on the Mediterranean shoots off a branch of mountains called in general the Apennines, which extends in a broad range through the middle of Italy to the farthest extremity. The northern portion of the country bounded by the Apennines on the S. and the Alps on the W. and N. is the vast plain of Lombardy which, for fertility, cultivation, multitudes of great cities, and general population, and natural riches, cannot be paralleled by any tract of equal extent in Europe. This tract is watered in its whole length of 250 English miles by the Po, navigable for large barges all the way up from the gulph of Venice, and receiving on both sides many considerable streams. The Tiber on antient fame in history, is more to be noticed for washing the walls of Rome, than for either its beauty or utility. It falls into the Mediterranean 14 miles below that city, to which, large barges and coasters can mount up the stream. The northern parts of the plain of Lombardy are adorned with a number of lakes between the roots of the Alps, of great extent and picturesque beauty. Other lakes of inferior note are found in the midst of the Apennines. The productions of Italy, a region situated between 46° and 38° of N. lat. comprehend every vegetable useful for the sustenance and the comfort of the inhabitants. The wines and oils of Tuscany have long been renowned. Besides the rich pastures of Lombardy furnishing the celebrated Parmesan and other rich cheeses, fields of excellent wheat are there seen, inclosed by hedge-rows of walnut, mulberry, and fruit trees, while the vines extend their clustering branches in festoons from tree to tree. The silk of Italy is well known in England.

To mention the cities and towns of Italy in their order from N. to S. Turin is the first to present itself, a very strong and uncommonly handsome regular town, of 80,000 inhabitants, on the bank of the Po, in the midst of a rich plain at the feet of the Alps. Genoa, a noted sea-port, distinguished by the richness of its

buildings and the beauty of its situation, contains about an equal population. Milan and Mantua, Placentia and Parme, Bologna, &c. Ferrara, are the chief of the many large and populous towns scattered over the plains upon the Po. Verona, famous for its antient amphitheatre, still entire within, Vicenza for its palaces erected by Palladio, and Padua the birth-place of the eloquent Roman historian Livy, were formerly ornaments of the territory of Venice, itself the most extraordinary city in the universe. Figure to yourself a cluster of low marshy or muddy islands, lying out in the sea, three miles from the nearest shore. Upon these spots scarcely above the surface of the water, a town founded upon piles has been constructed, large, and peopled with 160,000 souls. What in other towns would be streets, is in Venice all canals, not like those in Holland, or in some towns in Lincolnshire, with quays on the sides, but having the front walls of the houses rising immediately out of the water, and where only by *gondolas*, a kind of elegant wherry peculiar to Venice, can you move from one house to another. The grand canal winds through the heart of the town, crossed by a bridge of one spacious arch, and lined with magnificent public and private structures. St. Mark's place or square is the only space of ground of any size, on which, with some adjoining quays, the inhabitants can exercise their limbs in walking. A mile farther out is a range of sand islands, which serve to defend the town from the storms of the Adriatic.

Florence, the capital of the Tuscan territory, in the delightful vale of Arno, is remarkable well built and contains 80,000 people. The collection of statues and paintings, by the greatest artists, originally collected by the princes of the house of Medicis, but of late plundered by the French, was in some respects the first in the world. The Venus of Medicis was esteemed one of the most exquisite monuments of antient sculpture, known to modern times: it is now in Paris. Leghorn, a much frequented port on the Mediterranean, contains 30,000 people. It is impossible not to notice the harsh and absurd corruption of the name of this town, as used in England and other northern countries, most opposite to the melodious name employed by the Italians, viz. *Livorno*, from the *Portus Liburni* of antiquity. The Spaniards and Portuguese give it the same name, changed a little by the French to *Livourne*.

Proceeding southwards from Florence by Sienna, noted for the purity of its air and of its language, the cross surmounting the dome of St. Peter's church, appearing over the intervening heights, warns the traveller of his approach to ROME, the renowned mistress, until these later times, of the Christian, as in antient times, of the heathen world. Old Rome occupied the summits of seven low and flat eminences: that on which the celebrated capitol or senate-house stood being only 150 feet above the Tiber. These heights have long been abandoned, and the present city is chiefly confined to the level ground by the river, originally appropriated for the military exercises of the Roman youth, and thence called the field of Mars (*Campus Martius*,) together with a long narrow space

on the opposite or W. side of the Tiber in the vicinity of St Peter's church. The circuit of the present walls, as extended and repaired by the emperor Aurelian about the year 270, is nearly 13 English miles; but the town now fills only about one third of the inclosed space. The stupendous amphitheatre of Vespasian, erected, it is said, by the unfortunate Jewish captives carried to Rome after the utter subversion of Jerusalem in the year sixty-nine, and in which multitudes of the primitive Christians in combats with savage animals, or with human beings still more atrocious, sealed their faith with their blood;—the Pantheon, a circular temple of so remote antiquity as to have been only repaired and adorned under Augustus Cæsar, about the time of the birth of our Saviour, and still used as a church;—the other temples, theatres, triumphal arches, historic columns, Egyptian obelisks, the pyramid of Cestius, the only one out of Egypt, the public baths, fountains, aqueducts, bridges, and other monuments of antiquity:—the matchless fabric of St. Peter, the other churches and the palaces of the pope and the nobles, in which, until lately were assembled the most valuable specimens of antient sculpture, with the most masterly productions of modern times in every branch of the fine arts:—these, which barely to enumerate would require a volume, are some of the attractions presented to the scholar, the antiquary, and the connoisseur, in Rome and its immediate environs. St. Peter's is not merely the finest church in Rome, but the most magnificent structure in the world. Of its general appearance and distribution a good idea may be formed from visiting St. Paul's in London: but spacious as is St. Paul's, it would nearly sit length-ways in the cross aisle of St. Peter's, which wants but a little of 500 feet the whole length of St. Paul's; while the length of St. Peter's exceeds 700 feet. The following is a comparative list of the height of some of the most elevated buildings in the world, above the ground.

	Eng. feet
The summit of the greatest pyramid of Egypt	496.
The spire of the cathedral of Strasburg in France	457.
The cross of St. Peter's at Rome	435.
Ditto of the Invalid-hospital in Paris	346.
Ditto of St. Paul's at London	340.
The towers of the cathedral of Paris	218.

The population of Rome is estimated at 160,000. *Naples* is, after Paris and London, the most populous town in Europe (Constantinople here not considered) containing above 350,000 people. It is delightfully situated on the steep slope and along the foot of a range of richly cultivated hills, and on the shore from a noble bay from 12 to 15 miles in breadth, inclosed by hills and islands. The streets being in general narrow and steep, the interior of the town does not correspond to the beauty of the exterior. The mole is well constructed for the accommodation and shelter of merchant ships. The environs of Naples are highly interesting: the grand volcano of Vesuvius rising to the height of 4000 feet out of the

water, and extending by its roots quite to the town; the vestiges of *Pompey* and *Herculanum*, cities buried many years ago by the substances thrown out by Vesuvius; the volcanic ground on the W. of the town, presenting various mouths still discharging sulphureous steams and heated water; the remains of Roman towns, temples, palaces, &c. in the same quarter; the inexhaustible fertility of the surrounding country:—such are a few of the objects of instruction and curiosity, in addition to the monuments of modern art, and the antiquities drawn from the antient towns overwhelmed by the fire of the mountain, with which Naples furnishes the intelligent traveller. Although Naples lie in a very warm climate, yet the air is greatly refreshed by the sea-breeze which blows on shore through the day, so that the atmosphere is very healthy.

Italian Islands. These are chiefly *Corsica, Sardinia,* and *Sicily*. Corsica after a vigorous struggle with the armies of France, in aid of the Genoese, who laid claim to the sovereignty of the island, was at last subdued, and in the beginning of June 1769, the heroic Paoli and some of his fellow patriots abandoned the country. On the 15th of August following, was born in Corsica, under the French flag, and consequently a French subject, the second son of one of the best families in the island, *Napoleon Bounaparte*, whose rise, progress, and fall, will long occupy the attention of mankind. The island is of an oval form 90 miles long and 40 broad. It consists chiefly of lofty rugged mountains producing corn and wine, with quantities of iron, lead, and silver. Corte, in the heart of the country, was formerly considered the seat of government: but the present capital is Bastia, a sea-port on the N. E. coast. The inhabitants of the island are reckoned about 167,000.

Sardinia, separated from the S. end of Corsica by a strait of only a few miles in breadth. Its extent from N. to S. is 140 miles, and the general breadth 60. Many of the mountains are covered with snow for the greater part of the year; but there are wide valleys and spacious plains, which with due care and proper cultivation might be rendered very productive. As things are however, corn, wine, oil, oranges, lemons, and dates, are raised in considerable quantities. Silver, lead, granite, porphyry, are among the natural products, and the fisheries of tunny, sardinas, and anchovies, are of great value. The capital, Cagliari, possesses a good harbour at the S. end of the island: the population of the whole is computed to be 450,000. This island gives a title to an Italian sovereign whose usual residence is at Turin in Piedmont, in the N. W. of Lombardy. The present king has been lately restored to his dominions on the continent.

Sicily, an island of antient renown, is of a triangular form, the N. side being 170 miles, the S. side 160, and the E. side 130. It is separated from the south end of Italy by the strait of Messina, only a mile and a half over in the narrowest part. This island from its position in the midst of the Mediterranean, from the natural productions of a genial climate and a fruitful soil, might

now, as in days of yore, be the storehouse of surrounding districts: and it is to be hoped that the ameliorations lately introduced into the administrations, chiefly through the influence of Britain, will gradually restore this valuable island to the rank it deserves to hold among states. The population has been estimated at about a million. The capital, Palermo, a handsome port on the N. contains 100,000 people: the other towns, once so celebrated in history, Messina, Syracuse, Agrigentum, &c. are now greatly decayed. The most remarkable feature of Sicily is the formidable volcano, called by us from its antient name, Mount Etna, but in the country Monte Gibello. This mountain situated in the E. part of the island, rises to the height of 10,954 English feet, or above 2 miles perpendicularly above the sea; and the circumference of its roots extends above 80 miles. On the S. W. slope lies *Bronte*, the estate and duchy conferred by the king of the two Sicilies on our *Nelson*. The coincidence of the name and the situation of this place, with the character and the life of the hero on whom it was bestowed, is striking. Bronte stands on an eminence, round which the *lava* (the liquified substances) of Etna have often carried their destructive course, while the ashes and the thunder of the mountain passed harmless over the heads of the inhabitants. Now it so happens that *Bronte* preserves entirely the name for *thunder* in the language of the Greeks, once the inhabitants of that quarter of Sicily. The lower slopes of Etna are fertile, well cultivated, and populous; the middle region is clothed with forest; and the summit is covered with perpetual snow, in the midst of which is the great *crater* or mouth continually throwing up thick clouds of smoke, visible many leagues off at sea.

The sugar-cane is of great antiquity in Sicily; and the fountain of the nymph Cyane, near Syracuse, renowned in antient fable for her efforts to rescue Proserpine from the hands of Pluto, who, through an aperture where that spring rose, carried down his prize to the regions below;—this fountain still produces in abundance the *papyrus*, a reed supposed to belong to Egypt alone, and furnishing at once the materials and the name to *paper*.

Malta, antiently *Melita*, and celebrated for the shipwreck of St. Paul, as recorded in the end of the 27th chapter of the Acts, the scene being to this day pointed out by the inhabitants, lies about 60 miles S. from Sicily. The island is in length 20 miles, and in breadth 12: the whole being one mass of white stone covered very thinly with vegetative soil: but from the copious dews and vapours from the surrounding sea, and the moisture being retained by the rock, the crops of grain, cotton, oranges, and other fruits, are very abundant: such however, is the ordinary population of the island, that the corn raised scarcely serves for half the year. The cotton plant is sown in May and June, and reaped in October and November. The Maltese oranges are preferred to those of any other country of Europe. The body of the island is considerably raised above the sea, and surrounded by precipices rendering its approach, excepting in a few places, well secured, scarcely prac-

ticable. The principal harbour is that of the capital Valetta, so called in memory of the Grand master of the knights of Malta, who triumphantly defended the island against a very powerful attack made by the Turks in 1565. This is a very handsome town, situated on an elevated point of land separating and powerfully protecting the deep inlets of the sea on each side, forming the harbour. Malta is said to contain 60,000 inhabitants, independently of Gozo and the intervening Cumino, much smaller islands near its W. end. By the late peace on the continent, the possession of Malta has been confirmed to Malta.

The most antient possessors of Malta, of whom we have any accounts, were the Carthaginians, or the Phœnician colonists of the neighbouring coast of Africa; and from them the antient Punic language has been preserved, although with considerable intermixture of the Arabian, Norman, and Italian languages, to the present day. The order of warriors, instituted in the beginning of the 12th century, for the defence of Jerusalem against the Mahommetans, were in the progress of time, compelled to retire from the Holy-land to the island of Rhodes, on the coast of Lesser Asia. There they remained till the end of 1522, when, after a memorable resistance against the Turkish arms, they withdrew to Italy, and in 1530, were by the emperor Charles V. of Germany, established in Malta, for the purpose of defending the dominions of the Christian powers against the Mahometans. Thus the knights of St. John of Jerusalem, from knights of Rhodes became knights of Malta. By the invasion of the French in the late war, the knights were driven from their post; and, in the course of events, by measures on the propriety of which various judgments have been pronounced, Malta fell into our hands.

XIII. Turkey.

From the eastern shores of the Caspian sea or rather lake, in the centre of Asia, proceeded the *Turcomans*, a rude but warlike race of men who spreading themselves to the westward, at last passed over into Europe, and in 1453, the Turkish emperor Mahomet II. became master of Constantinople the capital, and of the greater portion of the Greek empire. Turkey in Europe is reckoned to contain 150,000 square miles: but the population of 6 or 7 millions is very inadequate to a country of such extent and natural advantages. Constantinople the capital was founded, or rather enlarged, by Constantine the Great, the Roman emperor, in the beginning of the 4th century, on and around the site of the antient *Byzantium*. The town is properly confined to a point of land washed by the *Propontis* or sea of Marmora on the S. and a long narrow arm of the sea, forming the harbour, on the E.; on the opposite side of which lie the extensive suburbs of Pera and Galata, where the Europeans chiefly reside. In front of the city passes the *Bosphorus*, or channel through which run westward the waters from the Black sea, for the Mediterranean, on the S. bank of which in Asia stands the suburb of Scutari. For beauty and

conveniency of situation few towns can compete with Constantinople: but the illiberal spirit of the Mahometan religion, and the despotic nature of the government, have rendered these advantages of little avail. The seraglio, or palace of the emperor, is an extensive mass of irregular buildings and gardens, finely seated on the advanced point of the city. The streets being in general narrow, and the houses of timber, the city presents few objects of curiosity except the Mahometan temples or mosques, (or rather as the word ought to be pronounced *moskees)* some of which were originally Christian churches, particularly that of Santa Sophia, erected by the Greek emperor Justinian 1300 years ago. The inhabitants of the whole town are computed to be better than half a million. The other towns in European Turkey, even Athens, and Corinth, and Sparta, the ornaments of antient Greece, Larissa, and Pella, and Thessalonica distinguished under the dominion of Philip and Alexander the Great of Macedon, are now but the shades of their antient greatness. Seated between the Mediterranean, the gulph of Venice, the sea of Marmora, the Black sea, and the mighty Danube, the Turkish dominions in Europe ought to be, but they certainly are not, the seat of industry, prosperity, and happiness. The religion of the state is that of Mahomet, but Christianity, according to the systems of the Greek church is publicly exercised in Greece, and in other quarters of the country. The Greeks also retain the use of their original matchless language, the language of Homer and of Xenophon, the language in which have come down to us the sacred scriptures of the *New Testament*, and the Septuagint version of the Old Testament. This admirable tongue is now however greatly debased by a mixture of terms and expressions, from the intercourse or dominion of foreign nations.

ASIA.

From a desire to lay before the reader a competent notion of the European states, that portion of the world with which he is the most connected, by the ties of religion, policy, commerce, and history, the descriptions and details have been of necessity drawn into considerable length. In noticing the three remaining quarters of our globe, however, similar enlargement is not required: the remarks on these parts will therefore be proportionably concise.

The grand portion of the old continent and the earliest peopled, called Asia, between the meridian of the E. coast of the *Archipelago* in E. long. 26° and that of East cape, within 30 or 40 miles of the N. W. parts of North America, E. long. 190°, that is, W. long. 170°. The most advanced point on the Northern or Frozen ocean, lies in lat. 77°, and the most southern point of Malacca is in lat. 2°. Asia must therefore include countries of all climates, and productive of every variety of animals, vegetables, and minerals.

Russian empire in Asia. This prodigious tract of country, comprehending Siberia and a part of Tartary, takes up the whole

northern portion of Asia. It is watered by the Oby, the Yenesei, the Lena, the Amoor, and other mighty streams; its chief products are timber, furs, and cattle, with salt, iron, copper, silver, and some gold.

Turkey in Asia, consists principally of the celebrated peninsula, called for distinction's sake Asia Minor, between the Black sea, the Archipelago, and the Mediterranean. In former times this fine country was thickly planted with great and flourishing cities. Troy and Ephesus have long ago disappeared: but Smyrna still maintains a numerous population as a much frequented port. *Jerusalem*, once so justly venerable on many accounts, is still a considerable town, held in almost equal respect by Jews, Mahometans, and Christians. The site of the famous temple is now occupied by a mosque: and within the inclosure of the church of the Holy sepulchre are pointed out various spots, noted as the scenes of occurrences connected with the death, burial, and resurrection of our Lord.

China, a very singular country on the E. coast of Asia, is of a square form 1550 English miles from N. to S. and 1450 from W. to E.: but in these limits are not comprehended sundry wide regions on the N. and W. either thinly inhabited or entirely desert. The population of this vast empire has been by the Chinese themselves carried to above 300 millions: by some European travellers the number is reduced to 200: but however this may be, it is unquestionable that the whole country seems to swarm with people, and the number, extent, and popularity of the cities, towns, and villages, is without a parallel on the globe, unless Holland be considered as an exception. Pekin, the present capital, situated close to the northern frontier, is a vast square town, reckoned to contain 2 millions of souls, or twice as many as London. Nankin, the antient capital, which gives name to the well known cotton stuff brought from China, is surrounded by walls 17 English miles in circumference. Canton situated on the E. bank of a great navigable river, in the S. of the empire, is the only port in China to which Europeans are permitted to traffic. The greater part of the country being an open plain, internal communication by rivers and canals is carried to a great extent. The tea-shrub, the porcelain, and the silks of China, are sufficiently known in our quarter of the world. Among the singularities of the country is the great wall, carried over hill and vale, along the N. and W. frontier, for an extent of 1500 miles; being in many places 15 feet thick, and 25 high: it is believed to have been constructed about 600 years ago, to keep off the incursions of the Tartars. The prevailing religion of China is paganism in different forms; and the language differs from every other in this respect, that the original words (in number about 1200, of which 326 are nouns) contain but one syllable: but by their combinations, and by the various modes of pronouncing them, a very copious language is produced.

India or *Hindoostan*. This most important part of Asia lies on the S. W. of China, consisting chiefly of a triangular peninsula, bounded on the E. and W. by the sea, and on the N. by ranges of lofty mountains, from which spring the great rivers Indus and

Ganges. In this vast region, the climate, although various, is warm. The hot or dry season begins in March, and lasts till June, when the rains commence and continue till September: the remainder of the year is generally pleasant. These periodical rains deluge the country, and cause the rivers to spread over the adjoining lands. The face of India is in general plain; the elevated range on the W. side called the Ghauts, not exceeding 3000 feet in height. The capital of the British empire in India is *Calcutta*, a large and populous place, supposed to contain more than a million of inhabitants of all sorts, on the E. bank of the W. branch of the Ganges, about 100 miles up from the sea: the largest vessels however, on account of the shifting banks of mud and sand in the river, remain lower down.

Persia. Adjoining to India on the W. lies a great country, comprehended by us under this general name, in many parts fertile in useful products, but much intersected by broad tracts of sandy desert. The capital, Ispahan, in the heart of the country, contains half a million of people. The Persians profess the Mahometan religion, and their language has long been celebrated for its beauty and expression. The horses are less swift, but more elegant than the Arabian; and the dromedary, or camel with one bunch, is very common. On the W. frontier towards the rivers Tigris and Euphrates, the lion seems to have fixed his abode, as also the leopard and panther; the latter frequently trained up when young, for hunting other animals. In the gulf on the S. of Persia, is a famous pearl fishery.

Arabia, much more spoken of than known, is a peninsula confined on the W. by the Red sea, on the S. E. by the Indian ocean, and on the N. E. by the gulph of Persia: it may be 1800 miles long, by 800 broad, but excepting along the coasts, particularly in the S. the whole consists of desert sands, destitute of water, and inhabited by only a few wandering tribes. Arabia produces very spirited horses, and the true camel, (with two bunches on the back,) aptly styled the ship of the desert, from his power of enduring hunger, and particularly thirst, so as to be able to transport over the desert the traveller and his merchandise. Arabia was in antient times noted for its fragrant incense and groves: but these were brought thither from India and Africa. It however, produces the finest coffee-tree, hence called Mocca coffee, as being chiefly shipped off from that port, near the mouth of the Red sea. The coffee-tree delights in hills and mountains, where its roots are dry; and the tree itself watered with gentle showers: it rises to the height of 16 or 18 feet, but when planted, as in the W. Indies, it is kept much lower, for the conveniency of gathering the fruit. The flowers grow in clusters at the root of the leaves, of a pure white colour, and very grateful odour. The fruit, the only useful part resembles a cherry. When it comes to a deep red it is ready for the mill, where it is passed between rollers where it is stripped of the outer skin, and divided into two parts or *beans* as they are called, from their figure. Then being sifted from the skin, the fruit is put into water and washed. When dried, it is ready for

the second or *peeling mill*, when the thin skin adhering to the fruit, is rubbed off; and the berries being properly winnowed and cleaned, are fit for sale. Different nations excel in the preparation of different articles of human sustenance. Thus, in this country, we understand the art of making tea. In Spain and Italy, chocolate is generally excellent: but the praise of making coffee in perfection is commonly allowed to France. In great families the practice is, to roast only as much at a time, and that with the greatest care, as will be wanted for a day; for by keeping roasted coffee, much of its rich fragrance goes off. A proper quantity of water is then boiled, and the ground coffee put into it. When the infusion has again just boiled, it is taken off the fire and allowed to settle, when the pure liquor is decanted into the coffee-pot, from which when gently heated, it is served out in cups. On the qualities of coffee medical men are of different opinions: it is allowed however, to be of a very grateful and composing nature, when the stomach is disordered, and takes off drowsiness. The late eminent physician, sir John Pringle, found a cup of very strong coffee, taken without sugar or milk, from time to time, during the fits, of great service in abating the paroxysms of the periodic asthma. The same substance is in constant use in the unhealthy marshes of Italy, as a remedy against the ague or intermittent fever. The most remarkable mountain is Sinai, from which Moses promulgated the religious and political system of the Israelites, near the N. end of the Red sea: it is still called *Gebel Mousa*, Moses' mount. Of the few towns in Arabia, Mecca and Medina are the chief; the former the birth-place of Mahomet, 30 miles from the Red sea, and the latter the place of his sepulchre. To this town the impostor fled in the beginning of his enterprize, and from that event, called by the Arabians *Hegira*, or the flight; the Mahometans of all countries reckon their time, the 1st year corresponding with the year 622 of the Christian era.

Asiatic islands. These are very numerous. Ceylon, near to the S. point of India, is of an oval shape, 270 miles from N. to S. and 150 in the middle from W. to E. The centre of the island is mountainous, and still possessed by native princes; but the shores are level, and now in our occupation: Colombo on the S. W. is the seat of government; but Trincomalee on the N. E. is the principal harbour: Jafnapatam is another British station at the N. end of the island, to the S. W. of which is the famous fishery of the pearl oyster; the shells being brought up from a great depth by natives of the neighbourhood, expert divers, who, by early habit, can remain a considerable time at the bottom of the sea. The most valuable vegetable production of Ceylon is cinnamon. It is the bark of a species of bay-tree, the best sort belongs to the *laurus cinnamomum*, the inferior or spurious sort, to the *laurus cassia*. The true cinnamon has a large root, dividing into branches, but without smell or taste: the body of the tree grows to the height of 20 or 30 feet, and is covered, as well as the branches, with a bark at first green, but afterwards red. The leaf is longer and broader than that of the common bay: the flowers are small

and white, in bunches at the end of the branches, having much the smell of the lily of the valley. The fruit is like a small acorn. What we call cinnamon is the under bark of the tree, separated from the rough outer bark in the spring, when the sap is abundant: it is cut into thin slices, and curls up by the heat of the sun. The best bark is procured from trees of the age of three or four years. To be good, cinnamon ought to be of a fine grain, smooth, brittle, thin, of a yellow colour inclining to red, fragrant, aromatic, and of a pungent agreeable taste: the long slender pieces are most esteemed. Cassia bark on the contrary, which is often fraudulently mixed with cinnamon, breaks smooth, and not in splinters, and has a mucilaginous or gummy taste. The elephants of Ceylon are the largest animals of their kind, in the wood; and the oxen and cows are small, with a bunch on the shoulder. They are not uncommon now in England, where we very improperly call them buffaloes.

The other great islands of Asia are Japan, Borneo, Celebes, Java, on the N. W. end of which stands Batavia, a large but unhealthy sea-port, the capital of all the Dutch settlements in the East. Sumatra, where we have a settlement at Bencoolen, from which our pepper is drawn: being the produce of a creeping plant resembling the vine; the white pepper is obtained by stripping the outer husk from the ripe seeds. On the S. E. coast of Sumatra lies Banca, noted for its tin mines, discovered above 100 years ago. Farther to the eastward lie a number of islands, some very small, called in general the *Molucca* or *Spice islands*. Among these are *Banda*, &c. very small, but of great value, being the only places where the *nutmeg* grows to perfection. The nutmeg-tree grows to the size of a pear-tree, with leaves like the bay; it bears fruit from the age of ten to that of a hundred years. When ripe on the tree, the nutmeg has a curious and beautiful appearance: it is of the size of an apricot, and nearly of the same colour, with a similar mark round it. When perfectly ripe, the rind over the mark opens and discovers the *mace*, of a deep red, growing over, and partly covering, the thin shell containing the nutmeg, which is black. To the W. of the Banda isles lies *Amboyna*, a beautifully varied island, of which the great treasure is the *clove-tree*, growing to the height of 40 or 50 feet, with spreading branches, and long pointed leaves. In proper sheltered situations, the tree will produce 30 pounds weight of fruit every year; between November and February. At the extremities of the branches are clusters of flowers, at first white, then green, and lastly reddish and hard; in this state the flowers are called by us *cloves*, and by the French *clous*, names given from their resemblance to a short thick iron nail, in Latin *clavus*. As they dry they become of a dark yellow, and when gathered, of a deep brown. The flowers left on the tree grow to the thickness of an inch, and then dropping off, produce new plants, which, in eight or nine years begin to bear flowers. To secure the sole possession of this precious produce, the Dutch, while masters of these islands, were in the practice of rooting out all clove-trees, but what grew in Amboyna:

and even there when the harvest was plentiful, a part of the crop was destroyed, in order to enhance the value and price of what was preserved.

New Holland, New South-Wales, Botany-bay, &c. By these several names we understand an immense tract of land situated in the midst of the great southern ocean, nearer to the Asiatic isles than to any other land, but not considered as belonging to Asia. This country altogether lies between the parallels of 11° and 39° of S. latitude, and between 112° and 153° of E. longitude. The extent therefore from N. to S. is nearly 2000 English miles, and that from W. to E. nearly 2600. Of this region, as large as all Europe, little but the eastern parts have hitherto been explored, and these to no great distance within the land. It seems to be hilly but not mountainous, incumbered with forest and marsh. The animals in general partake of the nature of the opossum or kangaroo. The fore part of this animal is slender, and the legs short; but the hind part is thick, and the legs very long, serving to carry it along by long bounding leaps, with considerable speed. Under the belly is a bag or pouch, in which the young are suckled and carried about by the dam. The birds have in general the peculiarly formed beak of the parrot tribe. The black swan, once proverbially rare, is no stranger in this part of the world. *Botany-bay*, so named from the variety of uncommon plants there discovered, is an inlet on the E. coast, where the British first settled, in January 1788: but this spot turning out to be less convenient than had been supposed, another settlement was begun, twelve miles more to the northward, on an excellent bay and harbour called Port Jackson, on the south side of which is a creek called Sidney Cove, where the colonists are now established. The original natives of this remote region are apparently but few in numbers; and in many respects but little superior to their four-footed comrades of the forest. About 1000 miles E. from this country, lies the small but productive settlement of *Norfolk Island.*

Amidst the vast ocean extending from Asia to N. America, are the Sandwich isles, now rising into importance by the enterprising genius of a rude native chief. In one of these, the illustrious circumnavigator Cook came to his end, equally untimely and undeserved.

AFRICA.

This quarter of the globe, much larger than Europe but much smaller than Asia, little but the coast is known. Surrounded by the Mediterranean on the N. the Atlantic ocean on the W. and S. and by the Indian ocean and the Red sea on the E, it is connected with the continent of Asia, only by the isthmus of Suez, between the Red sea and the Mediterranean, only about 70 miles over. Situated between the parallels of 37° N. lat. and 35° S. lat. its extent from N. to S. is about 4600 English miles; its breadth from W. to E. where greatest, reaches from 15° W. long. to 43°

E. long. or 4350 miles. The south portion of the country contracts rapidly to a point well known by the name of the Cape of Good Hope, because, when the Portuguese in their exploratory expedition along the coast, came to that spot, they found they could turn round the land, and then conceived good hopes of accomplishing their projected course to India. This happened under the command of the renowned Vasco de Gama, in 1497. It is customary to consider the point called the Cape of Good Hope, as the most southern extremity of Africa: this however, is a mistake; for the cape lies in S. lat. 34° 29′, but about 100 miles to the E. is cape *Agullus*, or the Needles, lying at least 30′ farther south.

Egypt. This very singular country is the first entered by the traveller from Asia by land. To have some notion of this famous region, we must conceive a long narrow level valley, in general of a few miles in breadth, and hemmed in on both sides by rugged ridges of rock and mountain. Down the middle of this valley, flows the Nile, rising far to the S. in the heart of Africa, which, swelled by the periodical rains falling in the countries where it has its springs, spreads over its banks, and lays the whole valley under water. The rise of the water is perceptible in Egypt in May, and it continues to increase till the beginning of August, when the surface is raised 16 cubits, or about 25 feet above its ordinary level. When the waters have subsided, corn is sown on the rich mud they have deposited; and the fertility of Egypt in corn, formerly proverbial, is at this day still prodigious, notwithstanding every discouragement under which the poor husbandman can labour, from a government of the very worst kind.

The Nile flows through this narrow valley until it has passed the pyramids, and the capital Cairo: it then enters a country low on each side, and there divides into a number of branches, spreading out like a fan, by which its waters are conveyed to the Mediteranean. The outward branches on the E. and W. form with the sea a triangular figure, which being that of the letter D, in the Greek alphabet, thus, Δ and called *Delta;* this name was given to the intermediate tract of land; and has since been applied to similar triangular or fan-shaped tracts of other rivers, as those at the mouths of the Indus, the Danube, the Rhone, &c. The mouths of the Nile were formerly reckoned seven; but now two only are open for navigation to the sea, that on the E. by Damietta, and that on the W. by Rosetta. That it never rains in Egypt is a mistake; for in the Delta, rains are common: and even at a distance from the sea, copious and refreshing dews are produced for vegetation by the Nile. The capital of the country is Cairo, in the country called *Al-Kahira*, situated a mile back from the E. bank of the Nile, consists of narrow irregular streets, and is supposed to contain 300,000 people. *Alexandria*, a sea-port W. from the Rosetta branch of the Nile, occupies but a small part of the site of the famous city founded by Alexander the Great, above 300 years before Christ. Out before the town lies the island of Pharos, now joined by a bridge and neck of sand to the continent on

which stood the celebrated light-house, one of the wonders of the world. Alexandria will long be remembered by Britons, for the scene of their splendid achievements at, and subsequent to, the death of the lamented Abercrombie, who there fell on the 21st of March, 1801, in an action with the French, who had wantonly invaded the country.

Abyssinia adjoins Egypt on the S. towards the sources of the Nile, a vast region inhabited by a rude uncultivated people, who nevertheless profess a steady adherence to the Christian religion. The capital is Gondar.

Tripoli, *Tunis*, and *Algiers*, are the capitals of three districts along the S. coast of the Mediterranean, professing the Mahometan religion, speaking dialects of the Arabian tongue, and, to the disgrace of European nations, practising with impunity the most atrocious acts of piracy upon all of them that fail by shameful concessions, and even tribute, to purchase an exemption from the attacks of these lawless plunderers. Of these towns, Tunis and Algiers are large and situated in fruitful countries. Tunis is besides, distinguished as in some respects having succeeded to the splendid and powerful commercial state of Carthage: of this celebrated city, aqueducts, cisterns, and other vestiges still point out the position upon the coast, at no great distance from Tunis.

Morocco, or more properly *Marocco*, is an extensive Mahometan empire on the N. W. coast of Africa. The capital, of the same name, Fez, Mequinez, and the ports of Sallee, and Tangier, are the principal places in the country. From Morocco we originally drew the coloured leather known by that name: the best yellow is prepared in the city of Morocco, and the best red at Fez.

Senegal, *Goree*, *Sierra Leone*, *Guinea*, *&c*. Proceeding S. along the W. coast of Africa, we come to the great rivers, Senegal, and Gambia, by which, intercourse is maintained with the negroes in the interior. It is perhaps unnecessary to observe that, negro is not the proper name of any people or individual. The word comes from the Latin, *niger*, black, and is used in this sense by the Portuguese, Spaniards, and Italians. On this account, it is employed to indicate a peculiar race of the native Africans who inhabit the interior parts to the N. of the coast of Guinea, remarkable for the flat face, woolly hair, and black complexion. Their neighbours, along the S. coast of the Mediterranean, of Arabian descent, and called in general, *Moors*, from Mauretania, the antient name of a part of their country, are very different in complexion, features, and dispositions; much, however, of the savage barbarity of the Moors, must be ascribed to the unsocial spirit of the religious system of Mahomet. Between these two rivers lies Goree, a small British island, maintained for the protection of our trade upon the coast. At the angle where the land bends to the E. towards the coast of Guinea, is the British settlement of Sierra Leone, so called, from a range of mountains said to abound in lions, established with the laudable view of introducing the arts of civilized life among the unfortunate natives, for centuries past, until lately, barbarously carried off to labour for the European

masters of America, and other quarters of the globe. It will ever be a memorial of the grand principles of justice, humanity, and sound policy, which induced the British nation to take the lead of the nations of the Christian world, in putting a final close to the abominable traffic of our fellow-creatures. Under the term *Guinea*, we include a tract extending from W. to E. along the coast for 600 miles, divided into the Grain, or Windward, the Ivory, and the Gold coasts, names expressive of their several products. In former times, the whole was known as the Slave coast; but that article of merchandise is now prohibited by Britain. From the E. end of Guinea the land runs S. to the Cape of Good Hope, on which, at Benin, Congo, Loango, &c. the Portuguese have long been established: but, instead of improving the natives, they seem rather to study to rival them in many of their least commendable propensities. Nor have the Portuguese taken much pains to communicate to the world what they have learned of the interior of that quarter of the country. The town of *the Cape of Good Hope* is situated in the bottom of a bay, opening to the N. W. called Table Bay, from a remarkable flat-topped mountain in the neighbourhood. The town is large and well built in the Dutch manner. The landing-place from ships, is at a small wooden quay near the fortress, which, with another, defends the habour. The Dutch territory, when it fell into our hands, extended 600 miles from W. to E. and 250 from S. to N. The white inhabitants are reckoned at 20,000. On the S. E. of the town lie the vineyards producing the Cape, or Constantia wine, the fruit of vines originally carried over from Burgundy, and the banks of the Rhone. The natives of the country have been often described under the name of Hottentots, a term intended to convey a notion of their language, which is described as hardly coming within the rank of the articulate sounds of human beings. That part of Africa lying along the Indian ocean, is inhabited by different tribes, of whom little more than the names are known. The vast internal parts have never been visited by Europeans, excepting some portion of the banks of the great river Niger, which flows E. across the broadest part of the country, and is supposed to be lost in some internal sea, which, like the Caspian in the heart of Asia, has no visible discharge or communication with the external ocean. The travels of our adventrous countrymen Browne, the unfortunate Mungo Park, of Horneman, &c. have furnished us with sundry very important lights on several parts of North Africa; while those of Barrow, Paterson, Sparman, Vaillant, and lately of Campbell, have made us well acquainted with the country round the cape of Good Hope.

African islands. Of these, the principal is *Madagascar*, 900 miles long by 200, off the E. coast of Africa; the isles of France and Bourbon, still farther off, may also be regarded as belonging to the same quarter of the globe. To the same quarter belongs *St. Helena*, lying in S. lat. 15° 55', and W. long. 5° 40', about 1400 English miles W. from the coast of Africa. The greatest extent of the island is 8 miles; the surface of the island is very uneven,

and exhibits many proofs of its volcanic origin. It is laid out in woods, gardens, and pastures. James' town is situated in the entrance of a deep valley opening on the sea, affording the only practicable landing-place on the island. For every where else, the shores are lofty and precipitous, and the sea very deep.

The islands of *Cape Verd*, the *Canaries*, and *Madeira*, lie off the N. W. part of Africa: the Canaries are supposed to have been known to the antients, under the names of the Hesperides, and the Fortunate islands. Of these, Teneriffe is remarkable for its volcanic peak, soaring out of the waters to the height of 15,400 feet, or according to other measurements, of 11,500 feet. These islands as well as their northern neighbours, Madeira, &c. are celebrated for the quality of their wines. Madeira belongs to Portugal; but the Canaries, to Spain.

America.

The discovery of this important quarter of our globe, is due to the genius and heroism of *Christopher Colon*, better known by his latinized name, *Columbus*. He is believed to have been a native of Ferrara in Italy; but having been in the service of Genoa, he is commonly called a Genoese. According to the general opinion of geographers in his time, Asia was extended round eastward, far beyond its proper limits, so as to be brought within no great distance of the western coasts of Europe and Africa. This notion, united to a number of detached considerations and remarks, on the state of the western ocean, as indicative of the presence of land, led Colon to imagine, that by steering a course due W. from the mouth of the Mediterranean, he might open up a speedy communication with the E. parts of Asia, and particularly with India, from whence vast treasures had been brought by the Red sea, or over land, to Europe. Submitting ineffectually his ideas and projects to the Genoese, to France, to England, and to Portugal, he at last engaged with Spain, where he was furnished with a few ships and companions, in his singular enterprise. Sailing from Cadiz on the 3rd of August, 1492, and holding a course in general west, at last, after numberless obstacles from the mutinous spirit of his men, he, on the evening of the 12th of the following October, discovered Guanahani, now called Cat-island, one of the Bahama groupe, in N. lat. 24°. In the year 1499, after Colon's return to Europe, from a second expedition to the new world, one of his officers, an Italian of Florence, by name *Americo Vespucci*, was entrusted with a fresh voyage to the same quarter. Publishing upon his return, an account of the new country and of his discoveries, by a strange caprice of fortune, the honour of giving a name to the 4th quarter of our globe, was bestowed on Americo, and not on Christopher Colon, who alone had the slightest claim to such a memorial of his merit. America is therefore, now the name of the great western continent; but, our antient countrymen in the northern portion, have in some measure indemnified the memory of Colon, by giving the name of *Columbia*, to one of their newly-

formed states, that in which the capital of the whole union, the city of *Washington*, is situated.

America consists of two great peninsulas, the N. and the S.; united together in the middle by the mountainous isthmus of Panama, not above 30 miles broad, between sea and sea. This isthmus lies in N. lat. 9°, from which North America extends to the unknown regions towards the N. pole. South America, on the other hand, extends S. beyond the equinoctial to cape Horn, in S. lat. 55° 58′. Proceeding northwards, from the isthmus we come to the great Spanish dominions, called in general, Mexico. On the N. E. coast is the peninsula of *Yucatan*, noted for its logwood, mahogany, &c. Mexico proper contains many lofty mountains, some of them now burning, and produces abundance of corn, cattle, cotton, sugar, indigo, tobacco, and wine. Gold is also plentiful; but silver is the chief mineral product. The richness of these mines may be estimated from the fact, that the portions set apart to be the property of the crown, which is one-fifth of the whole, commonly produces two millions sterling, after all the defalcations which we may, without any breach of charity, suppose to take place in its management. The silver is usually transmitted to Old Spain in dollars (the coin which the Spaniards call *un pezo duro)* from the port of Vera Cruz.

The incomparable red dye, called *cochineal*, is the produce of those dominions. It is the female of a very small insect, of the nature of our common lady-bird, which lodges on a plant, called by the native inhabitants, *nopal*, and by our countryfolks in the West Indies, the prickly pear. The botanical name is *caetus coccinellifera*, and the flowers and juices are of a beautiful red colour The insects are placed on the plants in October, when the periodical rains are over, on the parts exposed to the sun. Each female affords a prodigious number of eggs, from which the young insects quickly spread over the plant; and no fewer than six generations are usually produced within one year. From the plants the insects are scraped into water, where they die, and are then dried in the sun. Sometimes they are dried in an oven; but this injures the beauty of the colour. The cochineal insect also feeds and multiplies in its natural state, on the *opuntias*, that grows wild and dies of itself. The colour drawn from it in this state is more durable, but less bright, than that before described: there is however, no advantage in the use of it; for though cheaper, a greater quantity is required in dying.

United States of North America. From the entrance of the gulf of Florida, in N. lat. 25° on the S. to the British colony of New Brunswick, in N. lat. 44° on the N. the sea-coast of these states, on a straight N. N. E. course is about 1600 English miles. Formerly, they were bounded on the W. by the great river Mississippi, running south to the gulf of Florida: but since the late acquisition of Louisiana on the W. of that river, the American government has scientifically explored, and taken formal possession, of the whole immense region stretching westward to the great ocean, which separates their country from the eastern coasts of Asia. An

imaginary and hitherto undefined line along the parallel of 45° and the great lakes, form the boundary with the British Canadian territories on the N. According to a computation of the number of inhabitants within the limits of the United States, made in 1810, the following table is drawn up, in the order of the population of each state.

States.	Inhabits.	States.	Inhabits.
Virginia	974,622	Delaware	72,074
New York	959,220	Territory of Orleans	46,576
Pensylvania	810,091	——of Mississippi	40,252
North Carolina	555,500	———Indiana	24,520
Massachusets	472,040	———Louisiana	20,845
South Carolina	415,115	———Ilinoise	12,282
Kentucky	406,511	———Michigan	4,762
Maryland	380,546	District of Columbia	24,028
Connecticut	261,942		
Tenessee	261,727	Total	7,206,202
Georgia	252,433		
New Jersey	245,255	Chief towns.	
District of Maine	228,705		
——of Ohio	227,843	Philadelphia	111,210
State of Vermont	217,913	New York	96,372
New Hampshire	214,469	Baltimore	46,485
Rhode Island	76,931	Boston	33,234

In the year 1791, the whole population of the United States was only 3,925,253; in 1801, it had increased to 5,291,047; in 1810, to the before-mentioned number nearly seven millions and a quarter; and notwithstanding the disordered situation of affairs, on both sides of the Atlantic, the number of inhabitants is believed to be greatly augmented at the present time. The capital of the whole union is Washington, a new city so named, to preserve the memory of the soldier and the statesman to whom, the American states are mainly indebted for their erection into an independent power. This city lies in the centre of the whole states, in N. lat. 38° 53′, and W. long. 77° 15′, within the district of Columbia, at the junction of the Potomack with another river, by which the largest ships are carried up to the wharfs. The streets are to be broad and straight agreeably to a judicious plan, and the *capitol* where the national business is transacted, the residence of the president of the Union, and the other public buildings were to be completed with great magnificence and taste. Philadelphia the capital of Pensylvania, lies on the W. bank of the Delaware, navigable for large vessels. New York is a very thriving sea-port, on an island at the mouth of the great river Hudson. Boston, the capital of the several states called in general New England, is

admirably situated for commerce, on a point advancing into the middle of a bay, spacious and secure. Charlestown in S. Carolina, is another port at the junction of two navigable rivers.

Christianity in various modifications is universally professed throughout the United States; for the Jews are not numerous. The constitution of the union provides against the establishment of any particular system as the religion of the state, perfect religious freedom is therefore a fundamental and characteristic principle of the American government. Public affairs are administered by a President and a Vice-President, both chosen for four years; a senate consisting of two members, chosen every six years, from each state; and a house of representatives from the several states and towns, renewed every two years. The legislative power is vested in the senate and house of representatives, and the executive in the President. It is highly deserving of consideration that, after the year 1794, when in Pennsylvania all capital punishments were abolished, excepting for wilful premeditated murder, offences of every kind seldom exceeded one-half of the number committed before that period.

British possessions. These confine with the United States on the S. and on all other parts are bounded by the sea, or the frozen regions of the N. pole. *Nova Scotia,* of which the capital is the sea-port of Halifax, and *New Brunswick,* containing the port of St. Andrews and Frederic-town, lie on the S. side of the great river St Laurence. On the N. of which is the province of Lower Canada, of which the chief towns are the city and fortress of Quebec, and Montreal much higher up, and both on the N. bank of the same river. Upper Canada extends much farther to the westward, containing York, in N. lat. 43° 35′ with an excellent harbour on the N. shore of lake Ontario. These vast regions are in general mountainous, with many forests, plains, and swamps: the southern tracts however are very productive. Among the trees is the maple, from the juice of which good sugar is made. The lakes which separate our dominions from the United States are of vast extent, and all fresh water. Beginning at the S. E. and taking them in order to the N. W. these lakes (passing over Champlain,) are Ontario, Erie, Huron, Michigan, Superior, Winipeg, Slave-lake, &c. &c. Lake Superior is not less than 360 miles long, by 120 in its greatest breadth. The waters of these lakes are in general so deep as never to freeze, even in that severe climate. The rivers of N. America are upon a very large scale. The Mississippi runs from N. to S. through the heart of the country for 1400 miles, uniting about the middle of its course with the Missouri a much larger stream, which rises 2000 miles farther to the N. W. The Ohio a gentle stream, flows 1200 miles to the S. W. to the Mississippi. The St. Laurence conveys to the Atlantic, by a N. E. course, the waters of all the great lakes just mentioned. Large trading vessels go up to Montreal 500 miles from the sea. The short stream that connects lakes Erie and Ontario, is famous for the great cascade or fall of Niagara. The river is broken into three parts by islands, so as to form as many falls, the greatest is

about 142 feet high, and the two smaller about 160 feet high: the whole breadth of the river and islands is about 1340 yards, or better than three quarters of a mile.

On the N. of the Canadas, lies the great inlet of the sea called *Hudson's bay*, where several British ports are established for carrying on the fur-trade with the natives of that dreary region.

North American islands. These are chiefly Anticosti, uninhabited, although large, and abounding in wood and fish, lying in the mouth of the river St. Laurence.

Newfoundland, a triangular island above 300 miles each side, the principal station, St. John's, with a good harbour on the S. E. The interior of the country is very little known; and the dense fogs in which it is almost constantly involved, disqualify it as much as the intense cold, for the raising of corn. Along the shores, and particularly on the great banks situated on the S. and E. of the island, is carried on the extensive cod-fishery, which has long proved a gold-mine for those concerned in it. The depth of water on the banks, is from 22 to 50 fathoms, while around them it is from 70 to 80. A great swell of the sea and thick fogs, point out the position of the fishing ground extending from S. W. to N. E. for 600 miles. The great fishery lasts from the middle of May, to the end of September.

Prince Edward island, formerly *St. John's*, lies on the N. coast of Nova Scotia. The country is finely varied, and much intersected by small rivers, forming commodious havens for shipping. The soil is fertile, and the climate is much more agreeable than that of the neighbouring continent, or islands. Charlotte-town is the principal settlement.

Cape Breton, another considerable island lies on the N. E. coast of Nova Scotia, containing the town and spacious harbour of Louisburgh. The climate and soil are both unfavourable for agriculture; the fishery, and a valuable coal-mine, are its chief recommendations. All these islands belong to Britain.

Long island, running E. for 120 miles from New York, is a productive portion of the United States.

West India islands. When Columbus first came in with these islands, he conceived he had at last arrived at the true India of Asia: hence they acquired a name extremely improper, but now too long consecrated by custom to be easily changed. The French generally call them the *Antilles*, from the Spanish and Portuguese *Antillas*. Situated in a semicircle across the entrance of the great gulf of Florida, separating the N. from the S. portion of America, these islands are occupied by various European powers. Jamaica, the largest British island, is in extent 170 miles by 60. A few years ago, the white inhabitants were estimated at 20,000, the free negroes and mulattoes, called the people of colour, at 10,000, while the black slaves amounted to 250,000. Kingston, on the N. shore of the beautiful and secure bay of Port Royal, is a place of great trade, and handsomely built, containing about 30,000 people of all kinds. The other principal British colonies are St. Christopher, commonly called St. Kitts, Antigua, Dominica,

Grenado, Barbadoes, Tobago, and Trinidad. Cuba, and Porto Rico, belong to Spain. Hispaniola, generally called St. Domingo, from a town on the S. coast, formerly was divided between the French and Spaniards: but during the disorders of France, the mulattoes and negroes assumed the sovereignty of the whole island, declaring themselves independent, and reviving the original native name of the island, which was *Hayti*. Guadaloupe, and Martinique, are valuable French islands. Of all these islands, the productions are in general the same, viz. sugar, rum, tobacco, cotton, coffee, &c.

South America consists in general of plains of vast extent, bounded by the sea on the N. and E. but separated from the W. coast by a prodigious chain of mountains, extending along the shore the whole length of the country. Parts of this chain (or in Spanish, *cordillera)* called the Andes, rise to a greater elevation than any others which have hitherto been properly measured, in any part of the globe: although it be probable that to the N. of India, the land may rise to a still greater elevation. (See the table of mountains.) Chimborazo, the highest peak of the Andes, lying almost under the equator, is nevertheless clothed with perpetual snow, to a perpendicular distance of half a mile down from the summit. To keep pace with the mountains, the rivers of S. America are likewise on a very great scale. The Oroonoko, the river La Plata, and above all, the Maranyon, commonly called the river of Amazons, surpass any conception we can form of a stream of running water. This last (the Maranyon) rises at the foot of the Andes, in S. lat. 11°, flows first N. W. and then bends its course E. and falls into the Atlantic under the equator, by a mouth divided by low islands. So broad is this vast body of water flowing through a low country, that for a considerable way up from the mouth, the land on one side cannot be perceived from that on the other. The tide from the sea is perceptible 600 miles up, the whole course of the river, the largest in the world, is not less than 3500 miles. These rivers, like the Nile, the Ganges, &c. annually inundate their banks to a great extent on both sides. The great regions of Caraccas, and New Granada on the N. of Peru and Chili on the W. of La Plata and Paraguay on the E. being three-fourths of S. America, belong to Spain. Quito, lying almost under the equinoctial, on a very elevated plain of the Andes, is a large and populous town. In this neighbourhood, above 70 years ago, French and Spanish mathematicians executed the necessary operations for determining the space on the earth's surface, corresponding to a degree of latitude. Lima is a large city within a few miles of the sea, at the western foot of the mountains. Porto Bello, and Carthagena, are noted ports on the N.: and Buenos Ayres, so called in Spanish, as markable for its good air and climate, on the S. shore of the mouth of the river La Plata, has for a number of years past, been much resorted to by British traders. Great part of the silver from the mines in the interior being exported from this river, it has thence obtained its name, which in Spanish signifies silver;

from which we have our *plate*. But the town the most noted is Potosi, situated on the E. side of the Andes, in S. lat. 19° 40′, in a barren mountainous tract, but by rivers having water-communication with Buenos Ayres. From this spot a million sterling of fine silver has been annually transmitted to Spain for these 250 years past. Besides silver, gold, copper, tin, and lead, are found in those countries; which produce also the kinkina, or Jesuit's bark, sarsaparilla, rhubarb, julap, sassafras, gum guayacum, and many other articles of prime value in medicine and the arts. The chocolate-tree, or *cacao*, is chiefly the growth of the western districts. The fruit resembles a cucumber, containing the nuts covered with a very sweet skin. The nuts are roasted in earthen pots and cleaned: they are then beaten in a mortar to a thick mass, which is afterwards ground down upon a stone to the utmost fineness. The Spaniards then mix in *vanilla*, the fruit of a plant of the country, cloves, cinnamon, and sometimes musk, or ambergris; and the paste being duly prepared, is put quite hot into moulds, where it soon consolidates. The larger these moulds, the better does the chocolate preserve its qualities; and being very liable to contract a scent from other substances, it should be carefully wrapped in paper and kept very dry. The grocers of Paris proceed differently: they choose the best nuts called Caraccas, because brought from that quarter on the N. coast of S. America, with which they mix a very small quantity of cinnamon, the freshest vanilla, and the finest sugar; but seldom any cloves or other spice. In England chocolate is usually made of the cacao nut alone, only some makers add a little sugar and vanilla.

Proceeding northward from the river La Plata, the great country of Brasil first presents itself, belonging to Portugal, but little known to other nations. It is of a triangular form, above 2000 miles a side. The capital is San Salvador, on the bay of All-Saints, *(Bahia de todos os Santos)* and thence often called in general Bahia. But much farther southward, is San Sebastian, on a capacious and well sheltered bay, the mouth of a river called Rio Janeiro, (January river) by which name the town itself is commonly designated. Brasil is in general a tract of great fertility; but much incumbered with forests, and its cultivation is greatly neglected. Besides sugar, cotton, coffee, cacao, ginger, pepper, &c. this country produces various materials used in dying, particularly the tree known by the name of Brasil-wood. Gold is also found in abundance: the diamonds of Brasil are inferior to those of India alone.

On the N. of the Maranyon commences a long tract of low land along the sea, called in general, Guiana; the south-east part occupied by the French, of whom the principal settlement was Cayenne, on a small island close to the land. From this place, Europe has long been supplied with Cayenne pepper, a species of capsicum: arnotto likewise is brought from the same quarter. The north-west parts formerly occupied by the Dutch, were much better cultivated. The country being chiefly composed of extremely rich soil, deposited by the numerous streams by which it is inter-

sected. The principal settlements are Paramaribo, on the river Surinam, which often gives name to the whole colony, Issequibo, and Demerary. The products are sugar, coffee, cacao, and cotton: also quassia, a very useful bitter, the ricinas, from which castor-oil is drawn, balsam of capivi, ipecacuania, and other valuable drugs. The caoutchouc, or Indian rubber, is the thickened juice of a tree of the same country. Dutch Guinea fell into our hands, during the late war.

In the southern extremity of S. America, have been seen the Patagonians, a singular race of people, of whose stature the most absurd stories have been circulated. The officers of a Spanish frigate, sent out for the express purpose of exploring that unknown region, in 1786, took particular pains to measure some of the tallest of that race, and found their height to be 6 feet 6 inches English; and that the generality were from 6 feet, to 6 feet 4 inches. Their bodies are broader, and their heads larger than might be expected from that size.

Sparated from the land of the Patagonians by a narrow strait, is a groupe of islands, seldom free from ice and snow, called Terra del Fuego, (the land of fire) not certainly from the heat of the climate, or from burning mountains, but from the numerous fires seen on both sides of the strait, when Magallanes, or Magellan, passed through it in 1520, on the first attempt ever made to sail round the globe. The most southern point of these islands, is cape Horn, or more properly, Hoorn, from the name of the town in Holland, whence the ship sailed, that first turned round that extremity of the New World. The severity of the climate in that inhospitable and desert region is the more remarkable, that cape Horn, lying in S. lat. 55° 58′, is precisely as far on the S. side of the equinoctial, as Edinburgh is on the N.

In a much more genial climate, in S. lat. 33½°, and 400 miles W. from the coast of America, lie two islands, known by the name of Juan (John) Fernandez, discovered in 1675. The largest, about 15 miles long by 6 broad, is a beautiful and fertile island; but chiefly remarkable as the solitary abode of Alexander Selkirk, of Largo in Fife, in Scotland, who, on a voyage round the world, being dissatisfied with his captain, was, at his own request, set on shore there with some arms and other necessaries, and there remained for the space of five years, till 1710, when he was relieved and brought home by an English vessel that put in there for wood and water. With the view of giving to the public an account of his adventures, Selkirk entrusted his materials to a writer of those days, Daniel Defoe, who, basely betraying his trust, suppressed the authentic narrative, and in its place produced the well-known and celebrated adventures, of *Robinson Crusoe*.

CHAP. XIV.

ASTRONOMY.

ASTRONOMY, a branch of science teaching us to explain the nature and motions of the Sun, Moon, Stars, and other heavenly bodies, is so named from two Greek words, signifying the laws of the stars. Astronomy has engaged the curious attention of men in the earliest times of the world. In the book of Job, probably the most antient writings in existence, allusion is made to some of the most remarkable stars, (very erroneously named in our common translation) as pointing out particular seasons of the year. Various systems have been invented to explain the appearances of the heavens: but that which is now universally adopted, was given to the world by *Nicolas Copernicus*, born at Thorn in Prussia, in 1472. A little before his death, in 1543, he produced his system, which he had anxiously concealed lest he should offend what were called the pious, but in fact, the ignorant scruples of his contemporaries. To the formation of this system, that eminent astronomer was led, by a consideration of the absurdities of the schemes prevalent in his days, aiding a few hints scattered in antient authors, concerning the opinions of Pythagoras, the celebrated Greek philosopher, who flourished 500 years before our era, and who, travelling into Egypt for instruction, there learned the true system of the universe which had been traditionally preserved among the priesthood, from the first ages of the world, while in other regions it was entirely forgotten and lost. This system was embraced by the learned of Europe in general. Galileo, of Italy, by the invention of the telescope, by which the heavenly bodies may be accurately surveyed, brought it within the power of Kepler, and other men of science, and particularly of Sir Isaac Newton, to establish the Pythagorean, or Corpernican system of the universe, upon the unalterable principles of geometry; and the important improvements of the telescope, by Gregory and Dollond, carried on to high perfection by the recent and

ingenious discoveries of Dr. Herschel, astronomer to his majesty, have left us nothing to wish for but an enlargement of mechanical powers, to penetrate still farther into the inconceivably distant recesses of universal space.

According to the system of the universe now received, the Sun is a globe of vast magnitude, occupying the centre of a number of circles, described round him by a number of other globes, of different magnitudes, but all much smaller than himself; which are in themselves destitute of heat and light, but which receive both from the sun, in proportion to their several distances from him. These bodies from their moving through the heavens were by the Greeks called *planets*, from a term signifying to wander about. Being placed at different distances from the sun in the centre, they of course perform their revolutions round him in different periods: but these periods are regulated by this law, that the square of the time of the revolution of one planet is to the square of the time of the revolution of another planet, as the cube of the mean distance of the first planet from the sun is to the cube of the mean distance of the other planet. Thus the distance of the planet Mercury from the sun is 37 millions of English miles, and he revolves round the sun in 88 of our days: the distance of the earth from the sun is 95 millions of miles; and she revolves round him in 365 days. The square of 88 days is 7744, and that of 365 is 133,225; again, the cube of 37 millions, Mercury's distance from the sun is 50,653, if therefore we state the proportion as 7744 to 133,225, so 50,653 to a fourth quantity, which will be 871,416: and if the cube root of this quantity be extracted will be 95, the number of millions of miles in the earth's mean distance from the sun. The annexed table shows several circumstances by which the various appearances of the sun, and the several planets in his system, may be explained. The first column contains the names of the several bodies, the 2nd the medium diameter of each, the 3rd their medium distance from the sun, the 4th the inclination of their orbits or paths round the sun, to that of the earth or the ecliptic, the 5th the inclination of the axis of each body to its own orbit, the 6th the period of their daily rotation round their axis, and the 7th their tropical revolution, or the period in which each planet completes its yearly course round the sun.

Table.

Names.	Diameters in E. miles.	Distances from the sun in E. miles.	Inclin. of orbits to Ecliptic.	Inclin. of axis to orbit.	Daily rotation on axis.	Yearly course round the sun.
			° ′ ″	° ′ ″	D. H. Min.	D. H. Min.
Sun	883,246			82.44.0	25.14.8	
Mercury	3,224	37. millions	7.0.0			87.23.14½
Venus	7,687	68.	3.28.35		0.23.21	224.16.41½
The Earth	7,930	95.	0.0.0	66.32.0	1.0.0	365.5.49
Mars	4,187	144.	1.51.0	59.22.0	1.0.39½	686.22.18½
Ceres	160	260.	10.37.57			1681.12.9
Pallas	80	266.	34.50.40			1703.14.0
Jupiter	89,170	490.	1.18.56	90. nearly	0.9.56½	4330.14.39
Saturn	79,042	900.	2.29.50	60.0.0	0.10.16	10746.19.16
Herschel	35,112	1800.	0.46.20			30637.4.0

Mercury. According to the foregoing table, the planet of our system nearest to the sun is Mercury, a globe of 3224 English miles in diameter, less than the half of the diameter of the earth. His mean distance from the sun is about 37 millions of the same miles, and he revolves round the sun in a trifle less than 88 of our days: but in how many of his own days, that is, in how many revolutions on his own axis, is hitherto unknown. When beheld from the earth, being so much nearer to the sun than we are, Mercury is so much inclosed in his rays, that it is only on particular and rare occasions that Mercury can be seen by the naked eye: it has therefore hitherto been impossible even with the best glasses, to discover any spots or other appearances on his body, by the motion of which his daily rotation on his axis might be ascertained. From his apparent vicinity to the sun Mercury never rises or sets more than 1 hour and 50 minutes before or after that luminary. The orbit or circular path described by Mercury round the sun is inclined to the ecliptic or the orbit of the earth, at a small angle of 7 degrees, so that he seems at one time to rise above, and at another to sink below a line joining the earth and the sun, and it is one of the admirable properties of the solar system, that no two of the planets move round him in the same plane, but all in paths inclined by very small angles to each other, the two minute lately-discovered planets Ceres and Pallas excepted: but these are perceptible only with powerful glasses.

Venus is a planet of peculiar brilliancy, and according to her appearance, before or after the sun, is styled the *morning* or the *evening-star.* Being nearly twice as far from the sun as Mercury is, Venus is so far removed from the circle of his rays as to be perfectly observable at all times, excepting when by her yearly course round him, she comes to be either between him and us, or immediately beyond him. She turns once round on her axis in 23 hours 21 minutes, which is therefore the length of her day, and that of her revolution round the sun, or her year, is 224 days 17 minutes, or a little more than 8 of our months of 4 weeks. If Venus be attentively observed she will present appearances similar to those of our moon when about her first and third quarters, for a reason that will be explained when we come to speak of the moon. Venus is very little less than the earth.

The Earth. This planet on which we dwell is the next in order of distance from the sun. Venus and Mercury performing their revolutions within our orbit, are commonly, but very absurdly, called *inferior* planets, while Mars, Jupiter, &c. moving in orbits beyond ours are called *superior* planets. The earth's mean distance from the sun is 95 millions of miles, and her revolution round him is performed in what we call a year, consisting of 365 days 5 hours 48 minutes and 49 seconds, or in 365¼ days: that is, an observer on the body of the sun would observe the earth (as we observe the monthly motion of the moon,) to complete her annual course round him in that time. This is the *tropical* year: but it would require a small additional time to bring the earth in a line with the same star where her orbit began; and this length-

ened or *sidereal* year would consist of 365 days 6 hours 9 minutes and 12 seconds: the tropical year however, is what is commonly understood by the term year. The earth has a *satellite*, that is, an attendant globe, the *moon*, to be afterwards described.

Mars. This planet the next on the outside of our orbit, is of a dull fiery colour, differing in that from all the others: his mean distance from the sun is about 144 millions of miles, his daily rotation on his axis is performed in 24 hours 40 minutes but his yearly course round the sun employs nearly 687 of our days.

Ceres and *Pallas*. Of these planets but lately discovered, and only visible with the best telescopes, very little is yet known: the only remarks hitherto made on them is that they are both extremely small when compared with the other planets, the diameter of Ceres being 160 miles, and that of Pallas only 80, and that both, particularly Pallas, move round the sun in orbits much inclined to that of the earth.

Jupiter is the largest planet, as far as is known, that revolves round our sun as a centre, his diameter exceeding 89 thousand miles, his circumference above 280 thousand miles, and consequently his body at least 1370 times as large as that of this earth. Great as is Jupiter, he turns round upon his axis with such velocity that his day is less than 10 of our hours: but his annual course round the sun employs 4330 of our days, or 12 of our years wanting 50 days. When examined through a telescope Jupiter presents a number of spots and long belts upon or near his surface, varying in position and magnitude, from which circumstances they are supposed to be ranges of clouds and vapours floating in his atmosphere. Jupiter is attended by 4 satellites revolving round him, as the moon does round us. The velocity of their motion however, far exceeds that of the moon, which revolves round the earth in 29½ days, while Jupiter's first or nearest satellite, takes only 42½ hours to complete its revolution, at the distance of 250 thousand miles from his centre, while our moon is but 240 thousand miles from that of the earth. Jupiter's 2nd satellite goes round him in 85¼ hours, the 3rd in 7⅛ days, and the 4th in 16⅔ days.

Saturn is smaller than Jupiter, but nearly twice as far as he is from the sun. Saturn's rotation on his axis is completed in 10¼ hours: but his yearly course round the sun employs 10,756 days, or nearly 29½ of our years. He is accompanied by no fewer than 7 satellites or moons, of which 5 have been long known; the 1st revolving round him in 45¼ hours, the 2nd in 66 hours, the 3rd in 4½ days, the 4th in nearly 16 days, and the 5th in 79⅓ days. But in the years 1787 and 1788 two other satellites were discovered, between his body and the 1st of his former five: the satellite next within is called the 6th, revolving round Saturn in 33 hours, and the 7th which is the nearest to his body, in 22¼ hours. Saturn examined through a good glass, presents an appearance different from that of any other heavenly body, resembling a narrow oval, and not a globe. This peculiar appearance, it is now known from observations of powerful telescopes, is produced by a broad thin

ring encircling his middle or equator, probably equally solid with Saturn himself, and reflecting the sun's light even more than his globe. The distance of this ring from his surface is equal to the breadth of the ring, each being one-third part of his diameter. This ring is now believed to consist of two concentric rings very close together, both revolving round the axis of Saturn, but in a little more time; for he turns upon his axis in 10 hours 16 minutes, while the rings take 10 hours 32 minutes 15.4 seconds. If the axis of these rings were directed towards us, we should see them forming a circle of light completely detached in every point from Saturn's body: but this not being the case, the rings even most inclined appear only as a long narrow ellipse.

Herschel, a planet so named from Dr. Herschel the eminent practical astronomer, who made it known to the world in 1781, is the most remote known body of the solar system: it was at first called the *Georgian star* and *Uranus*. This planet performs its course round the sun in 30,637 of our days, or nearly 84 years: and although his diameter be more than 35 thousand miles, so remote is he, even when nearest to the earth, as to be rarely visible without a good glass; his distance from the sun being twice that of Saturn, or 18 hundred millions of miles. Herschel is attended by 6 satellites or moons, to be seen only by the use of the most powerful telescopes; consequently little is yet known concerning them, excepting that they differ from all the other bodies in our system, in revolving round him from east to west.

The Moon. It was before mentioned that our earth has an attendant globe or satellite, called the moon, of which the diameter is 2180 English miles, not much more than one-fourth of that of the earth, and of course her circumference is 6848⅔ miles, her surface will contain 14,930,092.316 square miles, (mens. of surf. art. 8. and 12.) or almost one-thirteenth part of that of the earth, and her solid contents will be 261,648,336,679.506 cubic miles, (mens. of solids, art. 6.) not quite one forty-eighth part of the solid contents of the earth. The mean distance of the centre of the moon from that of the earth is about 240 thousand English miles. Were the earth immoveable in its place in the heavens, the moon would revolve once round it in 27 days 7 hours 43 minutes and 11 seconds: but as during this period the earth has been proceeding in her annual course round the sun, it will require 29 days 12 hours 44 minutes and 3 seconds, to bring the moon to the same position with respect to the earth, with that where her revolution began. This last period 29 days 12¾ hours, forms our month as indicated by the moon. A line joining the moon and the earth, does not always coincide with that joining the earth and the sun; that is, the plane in which the moon travels round the earth, is inclined to the plane of the earth's path round the sun; and this inclination is liable to variation, but the medium is 5 deg. 8 min. and 49 seconds. And as the moon goes round the earth 12 times in 354 days and 9 hours, while the earth employs 365¼ days in going once round the sun, this circumstance joined to the inclination of the paths, and other deviations occasioned by the mutual

attraction of the heavenly bodies, must cause the moon to pursue a very irregular path round us, as is seen in fact to take place.

The sun being the source of light and heat to all the bodies revolving about him, the moon possesses none but what proceeds either directly or reflected from the sun; consequently no part of the moon can be seen by us until it be illuminated by the sun's light. To understand the various *phases*, that is, the varying appearances of the moon, as seen by us, we must accompany her in one of her monthly tours round our globe. At the beginning of the month she is in a line between us and the sun; consequently the enlightened half of her body being turned to the sun, no part of it can be visible to us on the earth. In three days or so, having advanced some way in her orbit round the earth, and out of direction of the sun, to our left hand as we look at her, a small portion of the enlightened face of the moon becomes visible to us. This from the globular form of the moon must appear as a small arch of light, broadest in the middle, and tapering to a point at each end, bending outwards toward the sun. This appearance taking place when the illuminated portion of the moon *is growing larger*, it is thence called a *crescent*. When she has advanced so far that lines to her centre from those of the sun and the earth would form a right-angle at that point, one-half of the enlightened face will be seen by us; and she is vulgarly called a half-moon, although she has in fact only completed the 1st quarter of her course. From this point still proceeding from west to east the moon will exhibit to us more and more of her enlightened face, still semicircular towards the sun, and bounded on the opposite side by an arch more or less bent. In this position she is said to be *gibbous*, that is, hump-backed. Keeping on her course to the eastward, more and more of the illuminated parts will be seen, until at last having performed one-half of her path round us, and being in a direction directly opposite to the sun, the whole enlightened face will be laid open to our view, and she will appear a large bright circle. In this position, having completed her 2nd quarter, she is styled a full moon. Still advancing from west to east, and the earth being farther and farther out of the direction of a line from her to the sun, the whole enlightened face can no longer be beheld by us: the eastern side of the moon will preserve its semicircular appearance; but the western border of the light will become gibbous as before, and at last turn to a straight line, when the moon has completed her 3rd quarter, and lines from the earth and sun would meet in a right-angle at her centre, as was the case at the 1st quarter. From this position advancing towards the line joining the earth and the sun, the enlightened part of the moon's surface becomes less and less apparent, again assumes the shape of a cressent, rounded towards the sun, and at last coming in between him and us, the whole light is turned away and she is no longer visible: this is the point where her monthly course began, and is therefore called the *New Moon*. Did the moon revolve in the same plane that connects the sun and the earth, it is evident that every time she came between him and us, she would appear

to pass over his surface, and would consequently intercept a large portion of his light; thus producing an *eclipse*, a Greek term signifying want or defect. As the earth receives its light from the sun, this defect would properly be an eclipse of the earth: but from the antient practice of considering our globe as the principal body of the solar system, it is always called an eclipse of the sun. Again, if the sun, moon, and earth, were all in the same plain, when the moon came to be full, that is, directly opposite to the sun, the earth would then be in a line between her and him, and would consequently intercept his rays; thus depriving her of his light and producing an eclipse of the moon. But the plane of the moon's orbit being oblique to that of the earth, it frequently happens at both new and full moon, that she passes above or below the earth's orbit, and consequently is neither eclipsed nor causes any eclipse. When we look at a full moon her body appears very nearly as large as that of the sun: but this is caused by her short distance from us, compared with that of the sun; his being 95 millions of miles, nearly 400 times that of the moon, which is but 240 thousand miles. But the sun's diameter being also more than 400 times as great as that of the moon, it is evident that her shadow must be a cone terminating in a point; and even when the moon is nearest to the sun, and farthest from the earth, this shadow can never cover more than a small portion of the earth's surface; consequently an eclipse of the sun, caused by the intervention of the moon, can never be visible over any great part of the earth. When the moon is nearest to the earth, she sometimes completely covers the sun's body, and the eclipse then is *total*: on the other hand, when she is farthest from the sun, her body apparently smaller than his, suffers a narrow circle or ring of his body to be seen all around her; the eclipse is then called *annular*. In eclipses of the moon, appearances are very different. The earth being much larger than the moon, casts a shadow much longer and broader than hers, which entirely cuts off the sun's light from her for a very considerable time. But even in the midst of a total eclipse of the moon, her body is plainly seen of a dull brown colour. This circumstance inclined astronomers in former times to suppose the moon to possess some real light in herself, besides what she received from the sun. This appearance is now known to proceed from a very different cause, which will be understood by the following simple experiments. Take an empty bason into a room into which no light is admitted but through a small hole in the window-shutter. Place the bason so that the ray of light from the hole may fall within it on one side, at a point to be marked: then pour water into the bason, and the end of the ray will gradually sink down to the bottom of the bason, in proportion to the depths of the water. If the water be made a little muddy by a few drops of milk, and the air of the room be filled with dust or hair-power, the change in the direction of the ray will be the more sensible. Again, lay a piece of money, a small key, or any similar object in an empty bason, where the light is good, and move backwards till you lose sight of the object, hidden

by the edge of the bason. While you keep your place, another person must pour water gently into the bason, so as not to displace the object, and as the water deepens, the object will return to your view, and gradually rise higher and higher in appearance, although in fact it still retains the spot where it before was invisible. In the same way a straight stick, partly dipped into water, seems to be bent over at the edge of the water, the lower end being brought much more into view than it would be if it were in an empty vessel. Now these several effects and appearances can be explained in no other way than by supposing the rays of light and consequently the rays of our sight, when they pass obliquely from the thin air into the denser substance of water, to be bent more towards the perpendicular pointing to the centre of the earth, than they were before they entered the water. By being thus bent downwards from the surface of the water, a ray of light and sight is directed to a point formerly invisible, or at least below the direction of the ray when in the air only. On the other hand, a ray passing from a denser to a thinner substance or medium, as through glass into air, is bent into a direction deviating more from the perpendicular than when it was in the glass. Rays passing out of one medium into another, whether denser or rarer, in a direction perpendicular to the surface of the latter medium, pass through it in the same direction, without being bent to any part. The application of these facts to explain how the moon comes to be partially enlightened even in the midst of a complete total eclipse, is very simple. The rays of light from the sun, that fall upon the atmosphere of the earth, which is the most dense near her surface, will of consequence be bent inwards towards the perpendicular passing through her and the sun, and of course follow a new direction, by which a great number of rays will fall upon the moon when eclipsed by the earth, and will convey to her that portion of illumination by which we are enabled to see her, at the time when no ray directly from the sun can possibly reach her. This effect produced on the rays of light, and consequently on the rays of vision, is termed *refraction*, from two Latin words signifying to be broken backwards. From this property of the rays of light it happens, that in looking along the surface of the sea in the morning, the sun's body becomes visible before he be actually above the the horizon; and that in the evening he continues to be seen after he is in fact sunk below the horizon. A curious instance of the effect of refraction occurred several years ago, which produced considerable discussion. In carrying on the great government-survey of Britain, one of the surveyors observed early in the morning, with a telescope, from an eminence in the west of England, the position of the steeple of a village some miles off. After a few days, about noon, it became necessary to repeat the observation: but no steeple was now to be discovered. This change of visibility and invisibility was observed several times, until at last, it struck the observer that it could be produced only by refraction, which, early in the morning, when the steeple was involved in thick fog and dew, it was raised

up to view from the eminence: but at noon when the fog was dispelled, the air deprived of its dense moisture had so far lost its refracting power, as not to be able to elevate the top of the steeple above the adjoining land.

The moon is also partially visible to us, at times when no light from the sun can possibly reach the parts we see. Thus in frosty, or other very clear weather, when the moon is a few days old, and only a small portion of her enlightened face may be seen by us, the whole of the unenlightened part of her body can be plainly perceived, of a faint brown complexion. This partial illumination can be produced only by the reflection of the sun's light from the surface of the earth, which in this manner performs to the moon the same office that she does to us, in furnishing reflected light upon those parts of both globes which are turned away from the sun. And this office the earth performs much more effectually than the moon: for the earth's surface being about thirteen times as great as that of the moon, her power of reflection and the mass of light she reflects, must be just as many times greater than what the moon reflects to us. From the moon's presenting to us always the same face, in whatever part of her orbit she may be, it follows that she turns once round upon her axis in precisely the same time that she employs in turning round the earth, and consequently the moon's day is just equal to our month. If a candle be set on a table in the middle of a room, and that a convenient distance, I move round the table, with my face constantly turned directly to the candle until I return to the point where I began the circle; it is plain that I have turned once round upon myself, in the very same time in which I have turned round the candle; for in the course of the circle my face, by being constantly directed to the candle in the centre, must in succession have been turned towards every part of the room. Since we behold always the same (or very nearly the same) face of the moon, it follows, that only that face can ever derive any benefit from the sun's rays reflected from us, or from what an inhabitant of the moon would call earth-light, and consequently that those who dwell on the opposite side of the moon which we never see, can have no other light, when turned away from the sun, than such as we derive from the stars, about the time of the new moon. It must therefore, be a journey of no common interest, for an inhabitant of that side of the moon which is never turned towards us, to traverse a portion of their own globe (and the most remote will have only about two thousand two hundred English miles to go) to obtain a view of the earth, and enjoy the splendour of its reflected light. As the inhabitants of the moon must however, conformably to the wisdom and beneficence of the incomprehensible Author of all being, be adapted to the peculiar circumstances of the globe on which they dwell; the darkness in which one half of the moon is involved during her night, is probably the season of repose and sleep, after a day longer than our fortnight, in which the want of earth-light will not be severely felt.

The conjectures of ingenious men on the nature of the moon,

and particularly of her surface, have been various and opposite: but the opinion now generally entertained is, that the dark parts we observe are water, or some other substance similar to water; because water, we know, absorbs instead of reflecting the rays of light, and therefore must appear darker than land. An objection to this opinion arises from the fact that, by means of powerful glasses, hollows and pits of various shapes and sizes are discovered, preserving uniform positions and appearances, which could not be the case with pits or hollows, in any fluid like our water. That the surface of the moon is beset with mountains, or similar elevations, seems to be unquestionable. If her surface be surveyed with a telescope, a few days before or after the half-moon, that is, the 1st, or 3rd quarters, we discover, besides the fully enlightened part, a number of brilliant spots, or points, situated within the adjoining dark parts, like islands in the water. Continuing our observations for some time, these bright spots gradually increase in size, and at last, the space where they first appeared, becomes wholly enlightened, while other brilliant points begin to show themselves in the dark parts. This appearance is entirely similar to what happens on our earth. When the sun first rises above the surface, his rays first gild the tops of our highest mountains: but, as he ascends, the light falls lower down the mountain sides, until the whole, with the vales below, are fully enlightened, while other summits more to the westward, begin to share in the illumination, and this process is carried on during the whole of the earth's rotation on her axis, by which every point is in succession exposed to the rays of the sun. Judging of the moon from her resemblance to the earth, the brilliant spots we thus gradually discover, must be the summits of mountains, the elevation of which was formerly by much overrated, some having estimated the lunar to be much more elevated than the terrestial mountains: better observations have now shown, that in general the summits in the moon do not exceed half a mile in height, and that the highest hitherto observed, rises to the height of about a mile and a half. From certain peculiar appearances, it is probable that some of the lunar mountains are volcanoes. Dr. Herschel, in 1787, observed one in a state of eruption, the burning part being three miles in breadth: it appeared through his admirable telescopes, like a piece of burning charcoal, partly covered with a thin coat of white ashes.

That the moon has a very important influence on our earth, in various respects, has long been, and still continues to be a very general opinion: the state of the weather, it is supposed, in a great measure is governed, and may be foretold, by her constantly varying appearances. But this is not all; the human mind itself is imagined to be so far subject to the influence of the moon, that those unhappy persons who are periodically deprived of the use of their rational faculties, and again restored to the enjoyment of them, are even in the language of our laws, styled *lunatics*, that is, moon-struck. By some curious investigations of Dr. Horsley, the late bishop of Rochester, published in the Transactions of the Royal Society of London, the influences of the

substance of the moon on our atmosphere, are shown to be by far too unimportant to be taken into consideration in foretelling the kind of weather to be expected at the different points of her monthly course round us. And the notion of her effects on the human brain and understanding, seems to have been formed in the days of ignorance, from a fancied correspondence between the periods of mental health, and disease in lunatics, and the periodical motions and phases of the moon. One effect however, really produced by the moon, aided a little by the sun, is a matter of great importance, its appearances being constant, regular, and of great use in common life. This is the flowing and ebbing of the sea, or the tides, which were described under the article *Tides*, in the treatise on geography.

The seasons. By the rotation of the earth on its axis, by which all parts of its surface are, in succession, exposed to the sun's light, the appearances of day and night are produced: and, by her revolution round the sun once every year, the vicissitudes of summer and winter, of seed-time and harvest, perform their regular course. Did the earth move in a circle round the sun placed in the centre, she would be at all times equally distant from his body, and would of consequence always receive from him an equal measure of heat and light. Again, were the axis of the earth always perpendicular to the plane of her path round the sun, his influences would always be equally dispensed to the several parts of her surface, in proportion to their relative positions. The rays of heat and light would fall perpendicularly on the parts of the earth under the equator, would fall more and more obliquely on the parts on each side, in proportion to their distance from the equator, and at the poles, those rays would merely touch the surface of the globe, like the tangents of a circle, and pass on beyond her orbit. Such would be the consequences of the earth's rotation on an axis at right-angles, to her path round the sun in the centre of a circle. Neither of these suppositions however, are founded in fact: for owing to the mutual attractions of the earth and the sun, and the other bodies of the universe, her path round the sun is not circular, but elliptical. The eccentricity of her orbit, or the distance of the sun in a focus of the ellipse from its centre, is about one-sixtieth part of the medium distance of the earth from the centre. In her annual revolution round his body therefore, she is much nearer to him at one time of the year, than at another; and her nearest approach to the sun, happens at the time of our winter solstice, in the end of December. Of this we are assured from different causes: the truth of it is even a matter of common observation and measurement. We know that the magnitude of objects, as beheld by the eye, increases or diminishes in proportion as they are nearer to, or farther from, the observer: and by means of an apparatus connected with a telescope, the diameter of the sun's body is found to measure, in the end of June, 31 minutes, 34 seconds of a degree, whereas, in the end of December, the same diameter measures 32 minutes, 38 seconds. In the end of March, and September, when the distance from the sun to the

earth is the same, his apparent diameter is also the same, viz. 32 minutes, 6 seconds. Since this is the case, it may be naturally asked, how we in this side of the equator, should have the warmest weather when farthest from the sun, and the coldest when nearest to him. This is owing to this cause, that the axis of the earth, instead of being perpendicular to her orbit, is in fact, inclined to it at an angle of 66° 32′; consequently the plane of her equator forms with that of her path, or of the ecliptic, an angle of 23° 28′: this angle is called the obliquity of the ecliptic. The planes of the equator and the ecliptic, intersecting each other in a right-line that passes through the sun: and when the earth comes to the two extremities of that line, her axis being perpendicular to both, the sun's light shines equally over her surface from pole to pole. Day and night being then of an equal length, these periods are thence called the equinoxes, the vernal happening on the 20th, or 21st of March, and the autumnal, on the 22nd, or 23rd of September. The axis of the earth invariably preserving the same position, or being constantly directed to the same points in the heavens, the N. end for instance, always pointing within a very small distance of what we call the N. pole star; as the earth continues her course from the spring, or vernal equinox, and departing more and more to the southward of the plane of the ecliptic, the rays of the sun, which at the equinox reached just to the poles, now advance more and more beyond the N. pole, and come short of the S. pole. At last, on the 21st of June, the earth arriving at the point of her orbit where she is the farthest from the sun, begins to return back on the opposite side of her orbit, the sun shines over the N. pole, and falls short of the S. pole by a space of 23° 28′, equal to the inclination of the equator to the ecliptic. In this position, by the daily rotation of the earth, the parts on the N. of the equator have more, and those on the S. have less of the sun's light than at the equinox. The days on the N. parts are therefore longer than the nights, in proportion as the place of observation is nearer and nearer to the N. pole; while just the reverse happens to places on the S. side of the equator. The 21st of June we therefore call the summer solstice, because then the sun apparently stops in the angular departure from the earth. Proceeding in her course to the 22nd of September, the sun's light shines less and less over the N. pole, and more and more towards the S. pole; and on that day shines equally over the whole globe. Day and night are again each 12 hours long. Still going forward, the N. pole of the earth is now turned away from the sun, and the S. pole becomes illuminated: the day towards the N. pole is shortened, while that towards the S. pole is lengthened: at last, at the winter solstice, on the 22nd of December, the days and nights have mutually changed places. In the northern hemisphere the day is at the shortest, and in the southern, at the longest. From this point the earth still holds on her course, the sun's light receding from the S. pole, and approaching to the northern, till the vernal equinox, when shining from pole to pole as before, day and night are of equal length all over the

globe. Hence it is plain, that although the earth be really and sensibly nearer to the sun in the depth of winter than in the middle of summer, yet his rays falling very obliquely on our northern parts of the world, a comparatively small number only can fall on any given space, and even these that do touch, as being reflected from the earth with an equal obliquity, can have a very small power in heating the atmosphere around us.

Comets. Besides the celestial bodies already noticed, there are others also revolving round the sun, called comets, from the Greek term for *hair*, because some have appeared like long hair streaming in the wind from a human head. They move in ellipses as well as the planets, but extremely excentric, so that excepting in a very few cases, the proportion between the length and breadth of the ellipse has never yet been established; and their periods of revolution are so long and inaccurately known, that few comets have with certainty been twice observed. The changes of their appearance also render them very difficult to be recognized. They are only seen by us when they are nearest to the sun; and some are believed in their course to move far beyond our most distant planets. Some appear only as a faint vapour: in others the *nucleus*, or solid body is perceptible, amidst the gross atmosphere surrounding them. As they approach the sun they put forth the appearance of a beard or tail of luminous matter; always directed away from the sun. Of the real nature of comets we are entirely ignorant: but this much is known, that they are governed by the same laws by which all the other bodies in motion round the sun are maintained in their relative positions.

The paths in which comets move, in the greater part of their course, between their nearest approach to, and farthest retreat from the sun, so nearly coincide with a straight line, that they seem to be destined to fall upon his body: and that they really did so, as if to furnish him with fresh supplies of fuel, to maintain his exhausting but still renewed flames, was once the fond fancy of learned men. This notion however, has long been exploded; for we know that after a comet seems to draw so close to the sun, at least in point of direction as seen by us, as to become invisible on account of the superior light of the solar rays, after a certain interval the comet emerging from those rays, on the opposite side is discovered travelling back away from the sun, with the tail, or now rather the beard or hair, streaming before it, in general much increased in size and brilliancy, from the inconceivable augmentation of light and heat acquired by its near access to the sun. Another opinion was adopted that, although comets did not fall into the sun, yet in their return from him, they retreated far beyond our planetary system, never more to re-enter it. This was founded on the supposition that their path in their retreat was changed from a curve to a straight line, which consequently never could again turn to a curve. This idea, equally unphilosophical and inaccurate in point of fact, was overthrown by the observations and sagacity of sir Isaac Newton, who ascertained that in no part of its course did a comet move in a straight line, but in the cir-

cumference of an ellipse. This ellipse is extremely excentric; that is, its greater diameter is prodigiously longer than the less diameter: and the focus in which the sun is placed, is at a distance almost inconceivable from the other, which although far beyond the orbit of *Herschel*, the most remote of our planets, is still incomparably nearer to our sun than to even the nearest of his brother-luminaries, the fixed stars in the firmament. In the days of ignorance, and even among uninformed men of our own time, comets have been supposed to be only small temporary meteors, formed and kindled up in the lower regions of our atmosphere, such as those, which, under the ridiculous name of *falling stars*, we often see shooting athwart the heavens, in a cool night, or as those more humble, which hovering and flittering about on damp and marshy bottoms, *Will wi' the wisp, Jack wi' the lanthern, &c.* amaze, terrify, and mislead the darkling traveller. Other persons of the present day, to say nothing of all antiquity, would persuade us that comets are the commissioned ministers of heaven, sent to announce to mortals war, pestilence, famine, and other dreadful or extraordinary events. Better observations however, and more rational judgments, have at last restored the formidable, but innocent and probably beneficial comet, to its due station among the works of the almighty and beneficent Framer of the universe. This body is now acknowledged to be opaque, that is, dark and not transparent, of a spherical form, like our earth, the sun, moon, and planets, and to possess no light or heat but what proceeds from the sun. The nature of the luminous hair, beard, or tail, is unknown; but in several circumstances it resembles the appearances produced by the electric fluid.

From the various appearances assumed by comets in different parts of their course round the sun, it is very difficult to ascertain their identity when re-appearing after a long absence. Besides, from the position of the earth with respect to the comet and the sun, it may frequently happen that a comet may enter our orbit and turn round the sun, nay, even pass at no great distance from the earth in the day time, so as not to be visible by us: the period of its revolution must then being unnoticed, remain unascertained.

Fixed Stars. These bodies are easily distinguished from comets and planets, not only by their constantly remaining in the same position relatively to each other, but by the peculiarly bright twinkling light they send abroad. This dancing light occasions them to appear much larger to the unassisted eye, than when they are observed through a telescope, which excludes all atmospherical deception, and admits those rays of light alone which proceed directly from the luminous body. With the most powerful magnifying glasses, the apparently largest stars are reduced to mere brilliant points, wholly unsusceptible of measurement. Nevertheless to assist in describing and recognizing the fixed stars, they are distributed into seven classes, according to their magnitude in our eyes. Those of the greatest apparent size and brilliancy are said to be of the 1st magnitude, and so on to those

of the 5th and 6th magnitudes, which are the smallest perceptible to the naked eye in clear weather. Such as are classed in the 7th magnitude are also called telescopic stars, being discoverable only by good glasses.

In the earliest times, for the better knowledge of the stars, astronomers arranged them in various figures, called clusters, asterisms, or constellations, named after different persons, animals, or other objects of celebrity in those days, but without any consideration of the resemblance of the clusters to the objects they represented. By this mode of arranging the stars any one may be discovered in the heavens or on a celestial globe, just as readily as London or Constantinople on a map or terrestrial globe. Of these systems of stars or constellations, the antients reckoned fifty, to which the moderns have added twenty-four.*

The earth with her moon, and all the other planets move round the sun in orbits inclined to each at various angles, but all the principal bodies within a space not quite 16 degrees in breadth. This space or belt is called the *zodiac*, from the Greek term for an animal or living creature, because it passes over a number of constellations distinguished, with one exception, by the name of some human or other living creature. These constellations are twelve in number, and they are also called signs, each containing 30 degrees subdivided into minutes, seconds, &c. so that the whole circumference of the heavens contains 360°. The following table contains the mark by which each sign is known, together with its name in Latin and English.

---

* That the appropriation of names to certain stars and constellations is of the most remote antiquity is not to be doubted; and the generality of translators and commentators have assured us that, in the original text of the Old Testament, some of those with which we are acquainted are to be found even by name. Thus we are told (and the precise names are retained in our common Bibles,) that *Arcturus* and *Orion* and the *Pleiades* are distinctly named by the author of the book of Job, chap. ix. 9. and xxxviii. 32; also in Amos v. 8. The fact however ought to be stated that, in the original Hebrew, the terms thus rendered by others peculiar to the Greek language, are very difficult to be understood. The verse where they all occur is the 9th verse of the ix. chap. of Job, which may be thus expressed in our characters;—*ngoseh ngash, ve-kesil, ve-kimah, ve-hadre teman:* thus given in Latin by Dr. Richard Grey, *qui fecit nocturnum circitorem, et sidus torpidum, sidusque calidum, et penetralia austri:* or in English, (speaking of the Creator of the universe,) *he who made him who travelleth round by night, and the sluggish constellation, and the warm, and the secret chambers of the south.* By the nightly traveller we are directed to understand *Arcturus*, by the sluggard *Orion*, and by the warm constellation the *Pleiades* or *Seven stars*. By other commentators these Greek names are differently appropriated; but all are equally destitute of any solid foundation, and can therefore only mislead the reader.

Aries	Taurus	Gemini	Cancer
The Ram	Bull	Twins	Crab
♈	♉	♊	♋
Leo	Virgo	Libra	Scorpio
Lion	Virgin	Balance	Scorpion
♌	♍	♎	♏
Sagittarius	Capricornus	Aquarius	Pisces
Archer	Goat	Water-bearer	Fishes
♐	♑	♒	♓

The following are the marks of the planets, beginning with that nearest the sun.

Mercury	☿	Mars	♂
Venus	♀	Jupiter	♃
The Earth	⊕	Saturn	♄
The Moon	☽	Herschel, or the Georgium Sidus	♅

Ceres and the other very small planets lately discovered have not received any distinctive characters.

Agreeably to these characters it is usual to distinguish the days of the week in the journal of a ship's voyage, and in other writings where astronomy is concerned, as will be shewn in speaking of *Chronology*.

Besides the constellations, some of the most noticeable fixed stars have acquired particular names. The constellation called *Ursa major* (the great bear) is always above the horizon, in our northern climates, and in the northern part of the heavens. In this cluster are seven conspicuous stars, forming what is called

Charles' Wain: four of them forming the body of the waggon, or of the bear, and three running out like the shafts, or like the tail of the animal. The two stars in the back of the carriage, or in the front of the bear, are called the pointers, because they lie in a line pointing very nearly right to the *Pole star*, called by the Arabian astronomers, Alruccobah, being the last in the constellation *Ursa minor*, (the little bear) of infinite service in ascertaining the latitude of a place, especially of a ship at sea, when a good observation of the sun's altitude has not been obtained. This most useful star is not however precisely at the pole, or at that point to which the axis of the earth would extend if produced, being distant from it 1 deg. 44 min. The circle it apparently describes round the N. pole is therefore invisible to the eye: and it is a striking proof of the acuteness of obsevation in the Phoenician navigators, and other astronomers of the east, that they governed their course by the permanent position of the pole star itself, while the other mariners of the world were often bewildered in their choice of other celestial guides. Of all the constellations, none come so near to a resemblance of the object indicated by the name, as *Orion*, before mentioned. It lies across the zodiac S. E. from the Seven stars; with a little imagination the stars composing it may be made to express the figure of a warrior with his belt and sword, and the circumference of his shield. The cluster called by the antients the Pleiades, and by us the Seven stars, is well known: it is situated in the neck of the Bull, the second constellation in the Zodiac. This cluster notwithstanding its name, shows to the eye only six stars; but, by a telescope, upwards of seventy may be counted within its bounds. On a general look the whole stars in the heavens seem to amount to a multitude innumerable: but this is owing to the apparent irregularity of their positions, and to our inability of seeing more than one half of them at any one time. Astronomers however by accurate observation have discovered those visible by the eye alone, without instruments, to be about 3182. This was the number reckoned by the celebrated observer *Flamsteed*, whose residence on the hill in Greenwich park was converted into the Royal Observatory, from which we calculate the longitude of places on the globe.

Of the nature of the stars we can judge only by analogy, and suppose to be of the same nature, and probably of the same magnitude with our sun, each immoveable in his place, with respect to the other similar bodies, and possessing in itself a faculty of bestowing light and heat on a number of dark globes revolving round it, as our earth and the other planets roll round the sun. On the supposition that the stars are all of the same magnitude, their different apparent brilliancy can be accounted for only by their different distances. Every one knows that the relative positions of objects in the country, hills, towns, steeples, &c. undergo very sensible changes in our view, as we alter our situation in travelling, and that the change is always exactly proportioned to the distance of the several objects; those only a few fields off the road rapidly assume new positions relative to

us; but we must travel many miles before the distant mountains put on any striking alteration in their appearance. The mean distance of the earth from the sun or the radius of her orbit, supposing it a circle, is about 95 millions of miles; the whole diameter must therefore be 190 millions of miles, a space 23,750 times greater than the whole diameter of the earth itself, and certainly sufficient to produce some sensible change in the relative positions of objects, placed within any calculable distance of an observer situated successively at the two extremities of the diameter of the earth's orbit. Even this prodigious change of place however, produces no change in the appearance of the fixed stars. *Sirius*, in the constellation of the Great dog, (*Canis major,*) which in our quarter of the world never rises high above the southern horizon, is perhaps the most brilliant star of the first magnitude, and is therefore supposed to be the nearest to our sun. If with the best instruments his appearance and position relative to other stars around him be observed from the earth, when she is between him and the sun, and consequently nearest to the star, and be again observed as soon as visible out of the sun's rays, when the earth has arrived at the opposite point of her orbit, no sensible alteration in the appearance of Sirius, or of his situation with respect to the other stars can be perceived. An unanswerable proof this of the incalculable remoteness of our sun from even the nearest of his brother suns distributed over the inconceivable spaces of the universe.

Milky way. The starry heavens are begirt with a broad swathe or belt of whitish light, in some places separated into two smaller belts to be afterwards conjoined: hence it has its name in English; or as it is called by equivalent Greek and Latin appellations, the *galaxy* and the *via lactea*. This milky appearance is now known to proceed from the accumulated light of an innumerable multitude of stars, too remote (if we are not allowed to suppose them to be really too small) to be distinguished by the eye alone. Besides the milky way, in various parts of the heavens are seen small spots of a similar appearance, which, when examined with the telescope, are found to consist of clusters of stars, the assembled light of which alone is perceptible by our eyes: from their indistinct cloudy appearance, these whitish spots are called *nebulae*.

The spacious firmament on high,
With all the blue ethereal sky,
And spangled heavens, a shining frame,
Their Great Original proclaim.
Th' unwearied sun, from day to day,
Does his Creator's power display,
And publishes to every land,
The work of an Almighty hand.

Soon as the evening shades prevail,
The moon takes up the wondrous tale,

And nightly to the listening earth
Repeats the story of her birth:
While all the stars that round her burn,
And all the planets, in their turn,
Confirm the tidings, as they roll,
And spread the truth from pole to pole.

What though in solemn silence all
Move round this dark terrestrial ball?
What though no real voice or sound
Amid their radiant orbs be found?
In reason's ear they all rejoice,
And utter forth a glorious voice;
For ever singing, as they shine,
"The hand that made us is divine." ADDISON.

CHRONOLOGY.

One of the most useful applications of astronomy is the measurement of time, and the arrangement of its several portions, so as to ascertain the date of events occurring in the world, and to adjust their positions agreeably to the order in which they took place. This is the business of *chronology*, a term consisting of the Greek words *chronos*, time, and *logos*, reason or discourse.

The simplest and most natural way of dividing time is drawn from the regular succession of light and darkness, or of day and night, and of the apparent motions of the heavenly bodies. In speaking of time however, by a day we mean 24 hours, or the time of one complete rotation of the earth on its axis. The commencement of the day has, in different countries and at different periods, been reckoned in various ways; and an acquaintance with these is indispensable for a right understanding of historical account of important transactions. The most antient people of whom we have any accounts, the Babylonians and Chaldeans, the Indians, the Persians, the Syrians, began to count their day from sunrise. The civil day of the Jews began also at sunrise, but the day, as far as religious or sacred matters were concerned, began at sunset: and this latter mode was followed by their southern neighbours the Arabians, as also by the Athenians, the Gauls, and other European nations. From Pliny we learn that the Egyptians counted their civil day from midnight. As at midnight the sun is at his greatest depression below the horizon, and then begins to run his daily race till midnight again comes round, that seems to be the most natural commencement of the day: it was accordingly adopted by both Greek and modern astronomers, as Hipparchus, Copernicus, &c. and is now used over the greater part of Europe. The astronomical day as it is called, being that employed in astronomical calculations, begins not at midnight, but at the ensuing noon. Thus 9 in the morning

of Sunday, the 1st of January, 1815, according to our common computation from the preceding midnight, would by astronomers be reckoned the 21st hour of the Saturday, the 31st of December, 1814; and new-year's day would not be counted to begin till the end of the 24th hour, or noon of Sunday. This mode is followed in keeping a ships' journal at sea; the first 12 hours, or those from noon to midnight are denoted by P. M. (*post meridiem*, after mid-day,) and the second 12 from midnight to noon are marked A. M. (*ante meridiem*, before mid-day.) Formerly all over Italy, but of late only in the Papal and Venetian territories, the day was reckoned to begin at sunset; the 1st after which was 1 o'clock, the 2nd 2 o'clock, &c. Thus on the days of the equinox, the 21st of March and 23rd of September, when the sun set at 6 o'clock of our time, midnight fell at Venice at 6 o'clock, and the following noon, 12 hours later, at 18 o'clock. When the sun set at 3 quarters after 4 of our time, midnight happened at ¼ past 7 o'clock at Venice, and the following noon at 19¼ o'clock:—expressions sounding very stange in our ears, as well as the common question, At what hour is it noon to-day? The mode of counting time in Italy is now however most probably conformed to that of the other states of Europe, in consequence of the subversion of the antient governments by French invasion.

Among the Jews, the Greeks, the Romans, and some other nations, the day and night were each divided into 4 vigils or watches, because each division was the time during which a certain number of soldiers kept watch, or were upon guard, as we say. A watch is also used to signify the number of hours during which a certain portion of a ship's company are upon immediate duty. The antient watches began at sunset and lasted for 3 hours, the 2nd beginning at 9 in the evening, the 3rd at midnight, the 4th at 3 in the morning, and ended at sunrise, when began the 1st watch of the day, the 2nd at 9 in the morning, the 3rd at noon, and the 4th lasted from 3 in the afternoon to sunset. In the south of Europe, in Judea, and other low latitudes, where the difference between the setting and rising of the sun, in summer and winter, is much less noticeable than in this country, the vague division of the day was sufficiently accurate for ordinary purposes: but in ascertaining the precise occurrence of any event, as in those recorded concerning our Saviour and his apostles and disciples, in the New Testament, attention ought to be paid not only to the watch specified, but to the season of the year.

In modern Europe the day is divided into 24 equal parts (or two twelves) called hours, from the Latin *hora;* each hour into 60 minutes, each minute into 60 seconds, and so on by a continued division into 60 equal parts. From accurate experiment it has been found that in London, in N. lat. 51° 31', in a house elevated 113 feet above the level of the sea, when Fahrenheit's thermometer indicated a temperature of 60 deg. and the mercury in the barometer stood at 30 inches, a pendulum in length 39.1196 English standard inches (not 39.2 inches as is commonly supposed) would perform its vibrations precisely in one second of time; that is,

would beat 60 times in one minute, 3600 times in one hour, and 86,400 times in one day.

By observing the period elapsed between one new moon and another, was obtained the notion of a month; and agreeably to the intervals between the new moon, the first quarter, full moon, and the last quarter, the month was divided into 4 equal portions or weeks; each consisting of 7 days, because the month was rudely estimated at 28 days. But instead of 28 days, the moon takes 29½ days in her course from new to new, consequently 4 weeks want 1½ day to keep pace with the moon. The days of the week were named from their order, the 1st, the 2nd, &c. by the Jews and Greeks. The Romans gave them names from divinities, to whom they were in some manner consecrated; and partly in imitation of them, partly in imitation of our Saxon ancestors, who had likewise appropriated the days to divinities of their own, agreeing in many characters with those of the Romans, we have adopted names bearing a relation to both. The first day of the week the Romans called *dies Solis* (the sun's day) or Sunday, called also by Christians *dies Dominica*, the Lord's day, distinguished by astronomers and seamen by this mark, ☉: 2. *dies Lunæ* (the moon's day) Monday, ☽: 3. *dies Martis* (Mars' day) Tuesday from the German Tuesco, ♂: 4. *dies Mercurii* (Mercury's day,) Wednesday from the German Woden, ☿: 5. *dies Jovis* (Jupiter's day) Thursday, from the German Thor, ♃: 6. *dies Veneris* (Venus' day) Friday from the German Friga, ♀: and *dies Saturni* (Saturn's day) Saturday, called also by Jews and Christians *dies Sabbati*, being the Mosaic Sabbath, ♄. The Romans in the early periods of their state are said to have employed a year of only ten months: but this being at great variance with the solar year, two others were introduced in the beginning, making the following twelve, in which the reader will readily discover our own names, viz. Januarius, Februarius, Martius, Aprilis, Maius, Junius, Quintilis, afterwards Julius in honour of Julius Cæsar, Sextilis, afterwards Augustus, in honour of his nephew and successor Augustus Cæsar, September, October, November, and December. These last four months, as also Sextilis and Quintilis, were so called, as being, according to the meaning of the Latin, the 5th, 6th, 7th, 8th, 9th, and 10th months from Martius, originally counted the 1st of the year; a distinction afterwards conferred on Januarius. Such however, was the discordancy between the Roman computation and the true course of the earth round the sun, that in the year 45 before Christ, Julius Cæsar, greater, if possible, in his schemes for the benefit of the empire in the arts of peace, than in his exploits in the field, found it necessary to introduce a thorough reform in the Roman calendar, founded on the best observations of the motions of the earth, sun, and moon, which the want of instruments permitted astronomers then to make. Directing therefore the current year to run on for 15 months, containing 445 days, he at last brought the 1st of January to coincide with the proper place of the earth, in the ecliptic, agreeing with that day. This famous year, on account of the changes it occasioned in festivals and other

epochs went by the name of the year of confusion. The apparent course of the sun, that is, the real course of the earth from any given point in the ecliptic, Cæsar found to take up 365¼ days. As this quarter or 6 hours would in 4 years amount to 24, or a whole day, he directed every 4th year from the 1st of his (the Julian) period, being the year 45 before Christ, to consist not of 365, but of 366 days, by which the 5th year would again coincide with the sun. The additional day was not however added at the end of December but introduced after the 23rd of February. The Romans followed what to us appears a very unskilful, but to them a very useful mode of reckoning the days of the month. From about the middle of each they counted backwards from the first day of the ensuing month. This 1st day of March was the Kalends of that month, the last or 28th day of February, was called the day before the Kalends of March, and the 24th of February became the 6th before the Kalends of March. Here in order to lengthen the month of February to 29 days, and consequently the year to 366, Cæsar directed not only the 24th but also the 25th days to be both counted the 6th before the Kalends. Hence the year was called *bissextile*, as having twice the 6th, and we also call it *leap year*, because it passes over the bounds of common years; and the day thus introduced into February was said to be intercalated.

This Julian correction admirable as it was, still erred a little in excess. The true solar year, or the time employed by the earth in revolving round the sun, reckoning from any given point to the same point again, instead of being 365 days, 6 hours, we by means of our instruments know to be only 365 days, 5 hours, 48 minutes, 49 seconds. The motions of the earth and sun therefore, gained upon the complete computation of time, and occurred so much sooner than the calendar pointed out. Thus the vernal equinox, which in Cæsar's time happened on the 25th of March, took place on the 21st, at the time of the council of Nicœa, in 323: and in 1582, the equinox having still advanced so as to happen on the 11th of March, pope Gregory XIII. assembling at Rome the best astronomers of Europe, by their advice struck off 10 days in the month of October, directing the 4th day to be counted and called the 15th. This important correction being promulgated by the papal authority, soon after the change of religion took place in Europe, it was very absurdly rejected by most protestant states. Even in this land of science, and of liberality of sentiment on religious matters, such were the prejudices of many, that it was not until so late as the year 1752, that the Gregorian correction of the Julian year was publicly authorised and adopted, by an act of the British legislature. By that time another day had been lost, and 11 days were to be struck off, so that the 3rd of September of that year was declared to be the 14th of the same month. Some inaccuracies however, still subsisting, the year 1800, although bissextile, was reckoned a common year, and then 12 days being struck off, what before the Gregorian correction would have been the 1st of January, became the 13th. The difference between the Julian and the

present way of reckoning, or between the Old and the New Style, is now therefore 12 days. It is as ungracious and unkind, as it is difficult to wean ourselves from old attachments: but it will do no harm to the fast friends of the Old Style to consider; and it will be but an amusement to the younger reader to compute, in what future periods of the world, if the old reckoning be followed, Christmas will fall upon Lady-day, when upon Midsummer, when upon Michaelmas, and when again upon Christmas, when a whole year will be lost in the reckoning. This is a simple question of proportion: if in 1845 years (from Cæsar to the beginning of this century) the Old Style fall back 12 days, in how many years will Christmas fall on the 25th of March, 91 days, on Midsummer the 21st of June, 179 days, and so on.

In computing time, different nations have chosen different great and important events, from which they begin to count their years. The Jews originally did, and still do count from the creation of the world, from the flood, from the call of Abraham, and other remarkable occurrences, in the history of their nation, recorded in the Old Testament. The antient Greeks reckoned from the introduction of the celebrated Olympic games, which were exhibited every 5th year, at Olympia, a city on the western coast of Peloponesus, now the Morea in Greece: these games were of great antiquity, and having been discontinued for some time, were revived in the year before our era 776. The knowledge of the Olympiads is of great importance, as by them all the Greek historians, and even some of the Romans, regulated their chronology. Vestiges of this mode of computing time may be traced among the later Greeks down to the year 440 of Christ. The Romans usually dated events from the building of the city (U. C. or *ab urbe condita)* corresponding to the year 753 of the Christian era. The Arabians, Turks, and some other Mahometans, reckon their time from the flight of Mahomet, in the commencement of his appearance as a teacher of religion, from Mecca where he was born, to Medina where he was buried. This flight, or as it is called in Arabic *hegira*, happened in our year 622: but the Persians, although equally followers of Mahomet, count from the era of Jesdegird, beginning in 632.

Our common Christian era, commencing at the birth of our Lord, was not introduced until the year 532, by the labours of Dionysius of Rome. In settling this point however, so long after the event, he seems to have erred in placing Christ's birth 4 years later than the truth. If then the creation took place 4004 years before that event; (and this seems to be the best founded opinion in a vast variety entertained by learned men,) it must have happened 4008 years before our era: and the present year 1815, ought to be counted the 1819th year from the birth of our Saviour.

The following is a list of a few of the most important events in the history of the world, from the creation to the present time:

	Year before the common Christian era
The Creation	4008
The deluge or Noah's flood	2352
The calling of Abraham	1985
Moses born	1571
Cecrops founds the kingdom of Athens	1556
Cadmus carries Phœnician letters into Greece	1493
The Pentateuch or first five books of Moses written	1452
Tyre built	1252
Carthage founded by the Tyrians	1233
Destruction of Troy	1184
Dedication of Solomon's temple at Jerusalem	1008
Era of the Olympiads began	776
Era of the building of Rome	753
Maps and globes introduced into Greece by Anaximander	600
Tarquin the proud, the last king of Rome, expelled	509
Xerxes' expedition against Greece	481
Ezra restores Jerusalem, seventy weeks of years, or 490 years before the death of our Saviour	458
The history of the Old Testament closes about	430
Alexander the Great born	356
Sun-dial first erected in Rome	293
Dionysius of Alexandria began his era, being the first who ascertained the solar year to consist of 365 days, 5 hours, and 49 minutes	285
The first Punic war began	264
Hannibal invades Italy over the Alps	218
Paper invented in China	170
The first library formed in Rome	168
Corinth and Carthage destroyed by the Romans	146
History of the Apocrypha ends	135
Julius Cæsar's first descent in Britain	55
Cæsar defeats Pompey at Pharsalus	48
Celebrated library at Alexandria accidentally burnt	48
Cæsar murdered by Brutus and other conspirators	44
The *Saviour of the World* born	5

	Year after the Christian era.
The common Christian era, as settled by Dionysius, began on the 1st of January, Christ being then 4 years old	1
Jesus Christ baptized by John	29
He suffers at Jerusalem in the 33th year of his age	33
Claudius Cæsar's expedition to Britain	43
London became a Roman station	50

	After Christian era.
Christianity said to be introduced into Britain .	60
Jerusalem taken and utterly destroyed by Vespasian and Titus	70
Pompeia and Herculaneum overwhelmed by an eruption of Vesuvius. Pliny the elder dies . .	79
Agricola builds his wall between the Forth and the Clyde	85
Adrian builds a wall between Newcastle and Carlisle .	121
Silk first brought from India . . .	274
Wines first made in Britain . . .	276
The Franks, a German nation, settle in Gaul, which from them was called France	277
Observation of Sunday enjoined under Constantine the first Christian emperor of Rome . .	321
Constantine removes the seat of empire from Rome to Byzantium, thence called Constantinople . .	328
Roman empire divided into eastern and western .	364
Europe overrun by the Goths under Alaric . .	401
France formed into a kingdom under Pharamond .	420
City of Venice founded	452
The Mahometan era of the Hegira or flight of Mahomet from Mecca begins	622
England invaded by the Danes . . .	653
Glass first brought to England . . .	663
The Britons subdued by the Saxons . .	685
Computations from the birth of Christ used in history .	748
Charlemagne founds the western empire . .	800
Juries instituted in England . . .	979
Arithmetical cyphers brought into Europe by the Saracens: letters of the alphabet had hitherto been used .	991
Paper made of cotton rags in use . . .	1000
The Danes finally driven out of Scotland . .	1040
The conquest of England by William Duke of Normandy	1066
The tower of London built by him . .	1080
First crusade for the recovery of the holy land .	1096
Henry II. of England gains possession of Ireland .	1172
Glass windows in private houses in England . .	1180
A conjunction of all the planets at sunrise 16th Sept. .	1186
Magna Charta signed by King John	1215
Astronomy and geography revived by the Moors of Spain	1223
Commons of England first summoned to parliament .	1264
Parliament regularly held from this year being the 22nd of Edward I.	1293
Turkish empire founded by Ottoman . .	1298
Mariner's compass improved by Gioia of Amalfi .	1302
Gunpowder made by a monk at Cologne . .	1330
Gold first coined in England by Edward III. .	1344
Edward III. had 4 pieces of cannon at Cressy .	1346
Coals first brought to London . . .	1357

	After Christian era.
Wickliffe the English reformer flourished . .	1309
Canary Islands discovered by a Norman . .	1405
Painting in oil invented at Bruges by John Van Eyck	1410
Algebra introduced into Europe . . .	1412
Printing invented by Laurence of Hærlem who died in	1440
Constantinople taken by the Turks; Greek empire ends	1453
Glass manufactured in England . . .	1457
Engraving and etching on copper invented about .	1460
Printing brought to England by Caxton . .	1471
America discovered by Colon or Columbus . .	1492
Portuguese sail to India round the Cape of Good Hope	1497
Shillings first coined in England . . .	1505
Martin Luther began the Reformation . .	1517
First voyage round the world by Magellan's ships .	1522
Reformation introduced into England . .	1534
Variation of the compass discovered by Cabot .	1540
Reformation completed in Scotland by John Knox .	1560
Pope Gregory reforms the calendar . .	1582
Tobacco first brought to England from Virginia .	1583
Mary Queen of Scotland beheaded by Elizabeth .	1587
Telescopes invented in Germany . . .	1590
Decimal arithmetic invented at Bruges . .	1602
Union of the crowns of England and Scotland .	1603
Galileo of Florence discovers Jupiter's Satellites .	1610
Thermometers invented by Drebel in Holland .	1610
Logarithms invented by Napier in Scotland . .	1614
Circulation of the blood, established by Harvey: this had been suggested in France in 1553 . .	1619
Barbadoes the first British settlement . .	1625
Barometers invented in Italy by Torricelli . .	1643
Pendulums applied to clocks by Huygens . .	1649
Air-pump invented by Guericke Magdeburg .	1653
Restoration of Charles II. on the 29th May . .	1660
Royal Society of London established . .	1662
Tea first used in England . . .	1666
Newtonian philosophy published . . .	1686
Revolution began on the 5th of November . .	1688
Land-tax enacted in England . . .	1689
Bayonets first used by the French . .	1693
Bank of England established . . .	1693
Union of the kingdoms of England and Scotland .	1706
New style introduced into Britain . .	1752
Society for encouragement of arts, manufactures, &c. established in London . . .	1753
Transit of Venus over the Sun, 6th of June . .	1756
Cook returns from his first voyage round the world .	1771
United States of North America declare themselves independent	1776

	After Christian era.
Dr. Herschel discovers the planet called by his name .	1781
———————— two of its satellites .	1787
Revolution in France began . . .	1789
King of France deposed . . .	1792
United parliament of Britain and Ireland met for the first time on the 22nd of January . . .	1801
Peace between Britain and France signed 22nd of March	1802
Restoration of Lewis XVIII. and peace between France and the allied powers 1st of May . .	1814
Peace with N. America 24th of December . .	1814

CHAP. XV.

DRAWING, &c.

IT was the remark of the great ornament of the English school of painting, the late Sir Joshua Reynolds, that "there is no easy way to become a good painter." It is only by a patient and attentive study of the principles and rules of the art, and by a careful and intelligent observation of the manner in which those principles and rules have been applied in practice, by the greatest masters, that the young artist can ever be qualified to arrive at proficiency and fame in his profession. To guide and assist him in his progress, numbers of works have been published, containing excellent instructions on the theory as well as the practice of drawing and painting, in all their branches: and to these the professional student will naturally resort for information. The nature and the limits of the present publication compel us to restrict our observations within very narrow bounds: within these however, it may not be impossible to assemble such advices and remarks, as may serve for a foundation on which the young artist can rest his hopes for the attainment of skill and ability in that peculiar branch of painting which he feels himself best disposed to cultivate.

Perspective. Drawing means to trace upon paper, or other plain substance, a correct representation of objects, as they appear when viewed from one particular station or point of view. In this operation each part or member of an object must be shewn in its proper place and position, and in due proportionate magnitude to the other parts, and to the whole object itself. In laying down a plan of a square, a circle, or any plane figure however irregular, the several lines and parts are drawn by means of a scale and compasses; so that the representation exhibited on the paper, is strictly and geometrically accurate and true. In drawing of this sort however, the object is represented as it actually exists in nature, without any regard to the mode in which it appears to our

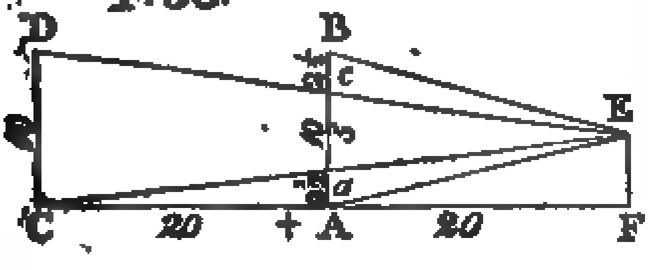
eyes. When we examine the plan of a town or an estate, the map of a county or a kingdom, the observer is supposed to be lifted up in the air, and looking down perpendicularly on every object in its turn, that draws his attention. It is not in this way however, that fields and buildings, mountains, rivers, and plains, appear to the eye in nature. On the contrary, all external objects present themselves to our view, in an endless variety of shape, colour, magnitude, and distance; according to our position with respect to them, to the state of the atmosphere in light or shade, and to various other circumstances which the attentive observer will readily discover. To give a faithful representation of objects conformably to all these particulars, is the proper business of drawing and painting. Infinitely varied however, as are the appearances of objects, the representation of them is by no means an operation vague, uncertain, or devoid of rule: on the contrary, it consists in the application of principles strictly geometrical, and resulting from the manner in which our sight is conducted: hence it is termed *perspective*, from Latin words signifying, *to look through;* an explanation sufficiently appropriate, as will be evident from the following consideration. Place yourself in a steady attitude at a convenient distance on the inside of a window commanding a view of the country: then with a proper instrument draw on the pane of glass the figures of the trees, buildings, mountains, animals, ships, &c. as they appear to the eye fixed in its station. If this be done with care, you will have on the glass a true perspective representation of those various objects, and the glass becomes the plane of the perspective. In this case the drawing is purely mechanical: but in representations on paper, canvas, &c. the plane of the perspective is imaginary, but the several objects are arranged in position, magnitude, colour, &c. agreeably to rules demonstrated in the science of perspective.

It will at first appear strange to assert, but it is certainly true, that with the single exception of one figure, we never see any object constantly as it really is. The only figure which, in all possible positions with respect to the eye, constantly presents the same appearance, is a sphere or globe; for in whatever point of view it is beheld, the outline is constantly round or circular. Plane surfaces on the contrary, as a triangle, a square, a circle, &c. never appear to be truly such but in one position, that is, when the eye is perpendicular to the centre of the figure. If the eye be held perpendicularly over the centre of a round table, the edge will appear perfectly circular: if the eye be moved side-ways until it be over the edge of the table, the circular form will disappear, and an oval or ellipse will take its place, the shortest diameter of which is always in the line passing through the centre of the table, from the point under the eye. Removing the eye still more to one side, and gradually sinking it down, the edge of the table will apparently form an ellipses, more and more contracted in breadth, until the eye come down to the level or plane of the table, when the ellipses will entirely vanish, and the

table instead of being circular will appear as a straight line, as broad as the edge is thick.

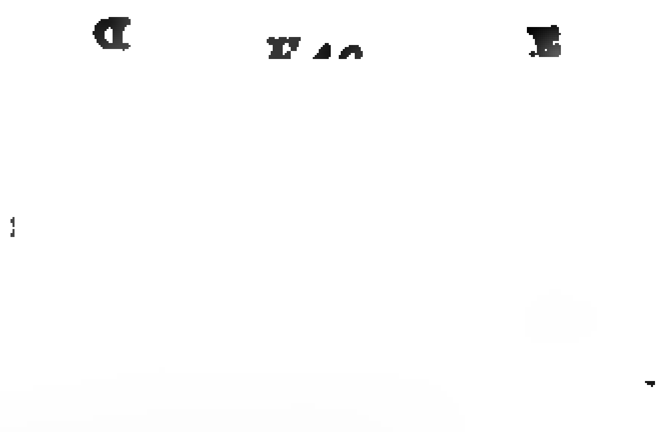
Abstracting all other circumstances, we usually judge of the size of objects by the quantity of the angle formed at our eye, by lines proceeding from their extremities: so that all objects beheld under the same angle, must be supposed and represented as of equal magnitudes. Take a pole ten feet long A B, and set it upright on the ground, at the distance of twenty feet from your station at E F. Fig. 38, then place another pole of 10 feet C D, upright in the same line at the distance of 40 feet.

F. 38.



Keeping the eye steady, cause an assistant to mark on the nearest pole the points *a* and *c*, at which it is crossed by the lines of sight to the top and bottom of the second pole. If you measure the distance between these two marks it will be just 5 feet, or one-half the length of the poles. But the distance of the 2nd pole was double that of the 1st, and the appearance of the 2nd is reduced to one-half of that of the 1st, if therefore the 2nd were removed to three times the distance of the 1st, its appearance would be reduced to one-third; if to four times the distance, to one-fourth, and so on. Hence it will be plain that, in order that objects should all appear of the same magnitude although at different distances, their size must bear a certain determined proportion to their several distances from the eye. If the 2nd pole appeared only as one-half of the first, because it was at double the distance; it follows that in order to appear equal in height with the 1st pole, it should be 24 feet long, or double the length of the first, and 36 feet long, or triple the length, if placed at triple the distance. In general in order to make objects at different distances appear of the same magnitude, that is, under the same angle at the eye, with some one object employed as a standard, the height, length, or magnitude of these several objects must bear to their respective distances precisely the same proportion with that of the magnitude of the standard-object to its distance. By attending to these effects of objects upon our eye, we will perceive the reason why lines strictly parallel, or every where equally distant, never appear to be so. If you look into a square box, Fig. 39, 12 inches a side and 60 inches long, open at both ends, the end next to the eye A B C D will form wide angles at the eye, while the opposite end *a c n o* will seem to form a small square opening in the midst of the first square, and the four sides of the box, instead of appearing to be at equal distances, will seem to be inclined and gradually tending to meet at the other end. If you

enter the end of a long avenue of trees as A B, Fig. 40, planted in rows on each side perfectly parallel, the end where you enter occupies so much space in the eye, that it cannot perhaps be all received without turning the head. If now you look to the other end, the rows of



trees will seem gradually to approach one another, until, if the avenue be very long, they appear actually to meet, as at C. But this is not the only deception; for supposing the trees to be all about the same height, those on each side next the eye, as A D and B C, will subtend a great angle of elevation, while those more remote will gradually diminish in height, and at last a line running along their tops will seem to unite with that of the ground on which they grow, and the trees themselves will apparently be shrunk to small shrubs. Similar effects will be observable on looking along a long line of straight road, along a long straight street of houses of uniform elevation, &c. This apparent mutual approach between lines every where equally distant, is not a deception of the sight, but really founded in the nature of things. The distance between two such lines, however far they may be extended, must always bear a real determinate proportion to their length; consequently that distance must always have a certain calculable magnitude: our sight however being unable, beyond certain limits, to perceive objects with distinctness, both the breadth of the avenue, and the height of the trees, vanish from our view; and the parallel lines by which the objects are bounded seem actually to meet in an angular point. If the eye be assisted by a telescope or perspective-glass, the apparent meeting of the parallel lines will be removed to a distance, greater and greater, as the power of the instrument increases: but as this is not the way to take representations of objects, parallel lines may, for every useful purpose, be considered and represented as mutually tending to coincide, at some very remote point; and on this supposition the practice of perspective is founded, because the error or fallacy is not an object within the reach of our senses.

An acquaintance with the principles of perspective is indispensably necessary in every species of drawing, not only of buildings and landscape in general, but of the human or other animal figures, flowers, machines, &c. &c. This necessity may not be evident to every young artist; but he will find that by some knowledge of this branch of science, he will be enabled to make much greater progress, and to keep at a greater distance from errors, often of the grossest kind, than if he had attempted to labour while entirely ignorant of the subject.

In perspective, sundry terms are employed in senses peculiarly

applicable to the subject, of which the following are the most frequently used. The *picture* is the paper, canvas, or other substance on which the objects are drawn. *The centre of the picture* is that point where a line from the spectator's eye falls perpendicularly upon the picture, or upon its plane produced if necessary. *The distance of the picture* is the space between the eye and the centre. This centre, it is to be observed, has no relation to the middle of the paper or canvas, with which it very seldom coincides; the spectator being generally placed much nearer to one side or to the bottom of the representation, than to the other side or the top. *The point of view* is the situation of the spectator's eye, raised a few feet above the ground, and the ground on which he stands is called the *station-point*. *The ground-line or base* of the picture, is that formed by the plane of the picture intersecting the horizon. The *horizontal line* is formed by the picture and a plane level with the spectator's eye. *The vanishing-point* is that in which two or more parallel lines, as observed from any particular station, would seem to meet; as was described in speaking of the appearances of an avenue, a street, &c. *Vanishing-lines* are those which in nature are parallel to each other, and consequently seem all to end at the same point. A perspective is said to be *parallel* when the plane of the picture is supposed to be parallel to a side of the principal object in the picture, as a building: in all other positions the perspective is said to be *oblique*. A *bird's-eye-view* is supposed to be taken by a spectator elevated in the air, or on an eminence, a steeple, &c. and looking down upon the objects below him. This differs from common perspective views, in having the horizontal line passing through the eye, raised a great way above the ground line, and even beyond the limits of the canvas or paper. Perspective is commonly subdivided into two parts *Ichnography* and *Scenography*; the first teaching how to make a perspective draught of figures on a plane, as the ground-plan of a building, and the second shewing how to draw solid figures, or such as are raised above the ground-plan.

Before the student attempt to draw figures in perspective, he is to consider well their forms and positions, relative to the picture. Surfaces in general may be reduced to the square and the parallelogram, and solid bodies to cube and parallelopiped. A cube may be placed in four different positions with respect to the picture: in the 1st and 2nd the cube is supposed to stand on a level plane, perpendicular to that of the picture, which is upright; in the 3rd and 4th positions the cube stands on a plane inclined to that of the horizon. In the first position, the nearest and farthest sides of the cube are parallel to the picture, and the other two sides, with the upper and lower surfaces, are perpendicular to it. In the 2nd, the upper and lower faces are perpendicular to the picture, and the other four are inclined to it. In the 3rd, two sides are perpendicular to the picture, and the remaining four are inclined to both the picture and the horizon. In the 4th position of the cube, neither the plane on which it stands, nor any one of the sides, is perpendicular to the plane of the picture. These are all

the positions in which any regular solid figure or building can appear: if the building be nearly equal in length, breadth, and height, it resembles the die or cube: but if the length, as is commonly the case, exceed the other dimensions, the building becomes a parallelopiped.

To lay before the reader any competent idea of the geometrical principles of perspective, would require a considerable number of figures and plates, occasioning an increase of bulk and price, incompatible with the nature and plan of this work. It must therefore suffice to mention that the true principles of the science were first accurately stated, in this country, by *Dr. Brook Taylor*, in a small work, which must not be confounded with the large treatise entitled *Brook Taylor's Perspective made easy, by Kirby*, of very inferior merit, and chiefly noticeable for the frontispiece, in which the admirable *Hogarth* has brought into one view examples of the most absurd and ridiculous blunders into which an artist may, nay, must fall, who is ignorant of perspective. An excellent explanation of Taylor's work was published by *Highmore*, in 1763. Persons unacquainted with geometry, or unwilling to bestow the necessary attention on that study, may consult many other works of later date, such as those of *T. and J. Malton*, *Noble*, *Ferguson*, *Priestley*, and others. By resorting to these works the young draughtsman will be furnished with a vast variety of examples for practice; but to *understand* the principles of perspective, he must apply to treatises where the subject is treated in a geometrical scientific way, especially to the little work of *Brook Taylor*.

That the young artist may however, have a general notion of the nature and effects of perspective, the following figure is introduced representing an antient castle.

The edifice is supposed to be a regular square, inclosing a court, and fortified by square towers at each corner, of which three only are seen, rising above the walls of the castle. The person who takes the view has his station at S, where he sees more of one side of the building than of the other. The level of the ground on which he stands is also that of the castle, and is represented by the ground line G L. The level of his eye 5 feet 6 inches above the ground, is represented by the horizontal line V V, raised that distance above G L. The only part of the drawing that can be laid down by measurement from a scale, is the corner *m n* of the tower the nearest to the observer. V V being the horizontal line of the eye, the space *s n* is made equal to 5ft. 6in.: *s x* the height of the body of the building, is set up 33 feet from *s* to *x*; and the additional height of the tower 16ft. 6in. will reach up from *x* to *m*, the whole height from the ground being 55 feet. The level of the eye being the line V V, in it will be found the points, at which all the vanishing lines of the building will meet; those above the level of the eye coming down to V V, as *m v e* V, and *m r* V, while those below that level rise up to it as *n a* V, and *n o* V: the vanishing points are V V; and in them meet all the lines which in the original building are parallel to each other; such as *n a* the foundation of one side of the castle, *x h* the top of the body walls, and *m v* the battlements of the towers. A line drawn from the observer's eye at S, at right angles to the plane of the perspective on the line V V, gives the distance of the picture, as S C, and C then becomes the centre of the picture. If from the station-point S, lines be drawn to the several angles of the building, as S *a*, S *z*, S *o*, &c. and these lines be cut by a plane R T, at right angles to the distance-line S C; upon this plane will be traced a correct perspective delineation of the castle; each part occupying a space on the plane of representation, proportioned to the angles formed at the eye, by lines from the original objects. From a consideration of the figure, it will be plain that the appearance and consequently the representation of the castle, must depend on the position of the observer: for had he been placed in a line perpendicular to any of the sides, no part of any other side could have been seen: had he stood in the direction of a diagonal running from the corner *n* to the outer corner of the opposite tower (not shown in the figure) both sides of the building would have appeared equally extended: and such is the effect of perspective, upon an eye accustomed to similar objects, that in the figure the shaded side conveys to the mind an idea of its being equally extended with the light side, although by measurement on a scale the latter be made equal to twice the extent of the former.

Of the effects of perspective, and of the manner of representing them on a plane surface, the student will form some notion from the following figures.

In Fig. 42. No. 1. let A B C D be a regular square, such as a marble pavement divided into compartments as there shown. This figure it is required to draw agreeably to the rules of perspective, on a horizontal plane, as it would appear to a spectator standing on the same plane, and at a distance from the middle of the outside of the square, equal to one-half of that side. Let B C the farthest side of the given square be also the nearest side of the intended draught, and let O in the centre of the square be the station of the observer. At such a distance as may correspond to the intended perspective, draw S V the horizontal line parallel to B C the side of the square. Draw a line from O the observer, to S the centre of the picture, perpendicular to S V, when O S will be the distance of the picture. Make S V equal to S O, that is, to the distance, and V will represent the point of distance. From the extremities of B C, draw B S and C S to the centre of the picture, and B V and C V. B V cutting C S in F, C F will be the depth of the square in perspective; and if E F be drawn parallel to B C, the figure B C F C will represent the given square A B C D, when drawn upon the line B C, and beheld by a spectator placed at O.

Again, let the spectator change his position from being opposite to the middle of the side of the square, to one nearly in the direction of the diagonal as at O in No. 2. of the same figure. In this oblique point of view the square must assume a very different appearance to the eye; and its correct representation is drawn in this way. From O set off O S to the centre of the picture, and making S V equal and perpendicular to S O, V will represent the point of distance. Then as before from B and C the extremities of the side of the square, draw B S and C S, and B V and C V. B V will cut C S in F, through which drawing E F parallel to B C, the figure B E F C will be the perspective plan of the square A B C D, as seen obliquely by a spectator placed at O.

Now (see No. 1.) the line O S cuts B C in the middle in *a*, and *a c* will represent the diameter of the square. B V will also cut *a c* in the point *t*, which will therefore be the centre of the perspective: if through *t* be drawn *n o*, that line will represent the contrary diameter; and the figure E F *o n* will represent the farthest half of the square, equal to the nearest half B *n o* C, although to an observer at O, it must appear much smaller, as in fact appears from the figure. It is evident that in whatever position the eye may be, with respect to the given square, by the same process a perspective draught of it may be laid down.

Materials and implements. In drawing we make use of various tools and substances, such as rulers, scales, and compasses: black-lead pencils and crayons of different colours; the latter so called from *craie* the French word for chalk, of which most crayons are made: the black-lead pencils are very improperly named, for the substance so called contains no lead, but is in fact a combination of iron with carbon, the essence of charcoal. Besides these, are pencils of camels' hair, India, or more properly, China ink, colours of different shades, Indian rubber, &c. The pencil is employed to draw the first sketches or outlines of the piece; and any wrong stroke with black-lead may be entirely effaced, by means of the Indian rubber,* or even with the crumb of stale bread.

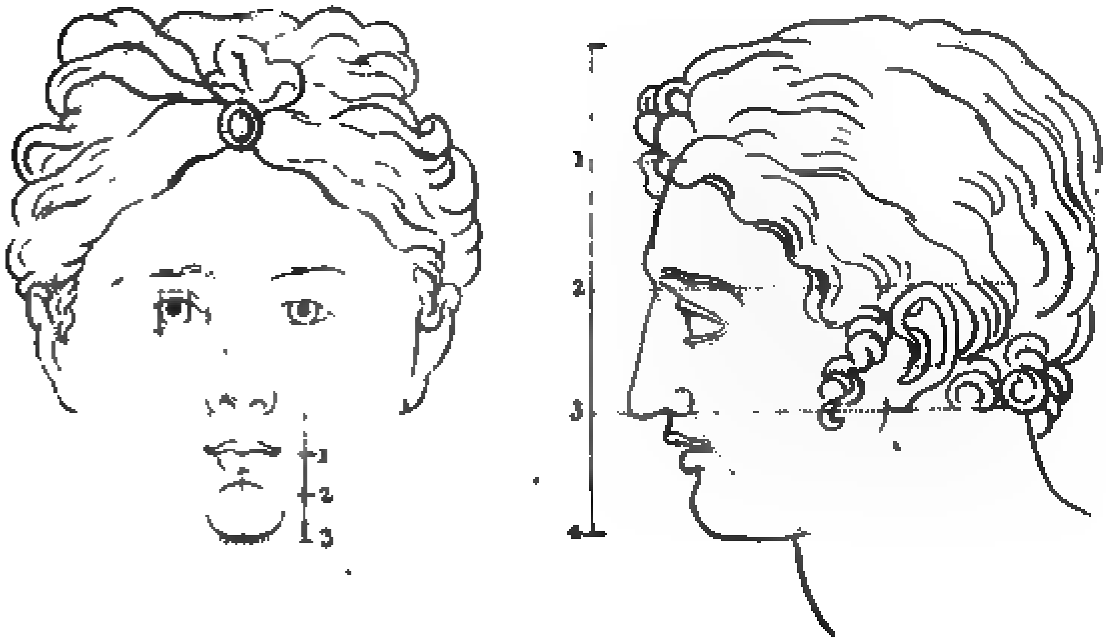
Lines, circles, and other geometrical figures. The first step for the young draughtsman is to practise and gain a facility in drawing such lines and figures, with accuracy and freedom, by the hand alone, without compasses or any other instruments: for in ornamental drawing the study of geometry is exactly what the knowledge of the letters of the alphabet is to reading and writing. In these exercises the beginner should work deliberately and slowly, carefully following

---

* This substance is chiefly brought from S. America, where it is called caoutchouc. It is the thickened juice of different trees, particularly the *syringa* or *iatropha elastica*; and was first brought to Europe about a century ago. Incisions are made in the tree, from which flows a milky juice, which is spread layer over layer, upon balls or moulds of clay, and then dried in the sun. The figures are next exposed to smoke, and when perfectly dry, the mould is extracted. The substance usually comes to us in the shape of bottles or bladders. When pure it is whitish, soft and pliable like leather, extremely elastic, and remarkably tough: it is also lighter than water. It possesses the property of removing lines and traces made with black-lead; and when dissolved in ether, it may be formed into various instruments, requisite in important operations of surgery. It is scarcely necessary to say that *caoutchouc* can very rarely be obtained unmixed with inferior substances.

DRAWING

Proportions.



Published by T. Kinnersley Feb 2u. 1815

the examples set before him; and when he has acquired a certain steadiness and readiness of hand, he may then, but still very cautiously, venture to work with greater speed. He should also accustom himself to draw his figures on a large scale, in order to arrive at a free and bold manner of designing: confining himself for some time to the mere outlines, without attempting to fill them up.

Drawing eyes, ears, heads, arms, &c. In this part of drawing, the pupil must copy the best lessons, of which great varieties have been published; particularly those contained in the present work, from the hand of an artist, whose reputation for eminent skill and experience, in all branches of his profession, is too well established in the world, to require specification in this place. It will suffice to apprize the pupil that, by copying and imitating the select specimens here given, he may be confident of following examples, constructed by the purest taste, on the strictest rules of art. So vast is the variety of forms exhibited by the parts composing the human figure, and consequently of that figure itself, that no certain rules can be given for their representation: it is therefore by long and patient observation and practice alone, agreeably to the best models, that he can acquire sufficient skill and facility in exhibiting them on paper. One general advice may however be given; which is never to finish the drawing, shading, or colouring of one member or part, until the whole figure be completely sketched out. By this course the defects of shape, situation, and proportion, will be just as perceptible, as if the several parts were completed, and they may be much more easily remedied. The pupil will therefore sketch out faintly the shape of the head, hand, &c. with the proper attitude and action; and then coolly considering the appearance and effect of the whole, he will proceed to insert the other features, joints, veins, &c. In all works of genius and art our first ideas, however lively and bewitching they appear to the imagination at the moment, are not always the most correct and judicious. Hence it is that great facility and great excellence of composition have so rarely been united. It will therefore be commendable in the young artist to lay aside his work, when just sketched out, for a little time, until his first conceptions have become moderate and given way to reflection; which will then point out defects and suggest improvements in his work, both of which, in the ardour and attention employed upon it, had escaped his observation.

Faces. The human head is usually divided into four equal parts: 1. that from the crown to the top of the forehead; 2. from thence to the eye-brows; 3. from the eye-brows to the bottom of the nose; 4. from the nose to the bottom of the chin. In a well-proportioned face this division is tolerably exact.

In forming a perfect face, the first step is to draw an oval, divided into two equal parts, by a line from top to bottom. Across the middle of this line draw another at right-angles; and on these two all the features must be placed. Divide the perpendicular line into four equal parts, allotting the uppermost to the hair, the next to the forehead, the third to the nose, and the fourth to the lips,

mouth, and chin. The cross-line or breadth of the middle of the face, is supposed to be equal to five times the length of an eye: if therefore it be divided into five equal parts, the middle part will be the space across the nose between the eyes, each of which will occupy the next two parts, and the last two parts will be distributed between the eyes and the edge of the face. This process will give a full face, that is, one in which every part is equally exposed to the spectator: but if the head be turned to either side, or upwards, or downwards, the arrangement of the features will be varied, according to the quantity of departure from the appearance of the direct full face. The top of the ear, when the head is erect and full, is on a level with the eye-brows, and the bottom with that of the nose. The nostrils should swell out no farther than the corner of the eye; and the middle of the mouth must always be placed on the perpendicular line of the face.

Human figure. When the pupil has made some proficiency in drawing the face and head, he is to lengthen the perpendicular line downwards to a distance equal to six times the height of the head; for the head is one-seventh part of the height of the whole figure. If the figure be divided into two equal parts, the upper will just comprehend the trunk of the body, and the lower, the thighs and legs: the knee is in the middle of this lower part. In measuring the upper half, the usual standard is the length of the face, which occupies three quarters of that of the head. The length of the body, below the chin is equal to three faces, reaching to the pit of the stomach and the navel. The thigh and leg are of equal length, and each contain two faces. Another measurement of the human figure is given in this way, by which it contains ten faces. From the crown of the head to the forehead is ⅓ of a face; the face itself is divided into 3 equal parts, containing the forehead, the nose, and the mouth and chin. From the chin to the pit between the collar-bones are 2 lengths of a nose; from this pit to the bottom of the breast 1 face; thence to the navel 1 face; to the end of the trunk 1 face; to the upper part of the knee 2 faces; the knee occupies ½ face, and from its lower part to the ancle 2 faces: from thence to the sole of the foot or heel ½ face. When a man's arms are stretched out, the distance from the tip of the middle finger of the one hand to that of the other, is just equal to the height of his figure; across the breast the breadth is 2 faces. The bone of the arm from the shoulder to the elbow is 2 faces in length; and from the elbow, the bone, including a part of the hand, as far as the root of the little finger, extends also 2 faces. The sole of the foot is the sixth part of the figure: the hand is the length of the face; the thumb that of the nose, as is also the longest toe.——In all these measurements however, it is evident that only general notions can be formed; for in no two human figures can the same precise proportions be discovered. Neither in representing *real* human beings, are we authorised to draw rules from the monuments of sculpture, which have survived the ravages of time, and in which the antients, the great masters of that art, have left us specimens of their skill and taste, hitherto unequalled. The incomparable

Pub.d by T. Kinnersley March 24 1815

MASCULINE FORM.

statue of Apollo, formerly in the Belvidere of Rome, and that of Venus, formerly in the Medici collection of Florence, but both now in Paris, were formed on ideas of imaginary proportions and beauty. In an attempt to represent beings, in whom were united all the perfections of which the human frame was conceived to be susceptible, figures have been produced, far surpassing in symmetry and elegance of form and expression any human being that ever really existed. On this subject however, various modifications are proper to be admitted, in drawing human figures, of which the following are the most important. In speaking of perspective, it was observed that, with the exception of a globe or sphere, no object either does or can present itself to the eye, in its real and true form: and it is only from experience and analogy that, from the appearances of objects, we are led to infer their genuine shape and colour. Two men, each six feet high, conversing together at the distance of five feet, will each appear under an angle corresponding to their known height. Let them go asunder to the distance of ten feet, and each will appear to the other under an angle one-half of the former, as if their height had been reduced from six to three feet. It is a common problem in practical geometry, to determine the height of a statue, to be erected on an elevated situation, which to a spectator below shall appear of the ordinary size of men, when standing on the ground, and at such a distance as to admit their features to be distinguished. Allowances are therefore to be made for the diminution of objects according to their distance, and to their elevation above the surface of the ground, and even above the level of the eye of the beholder. The dimensions of objects, it is true, are proportionally diminished according to their distance from the eye: but as the most striking characteristic of the human body is its height, to present this feature, in the most favourable way, is therefore of the highest importance. In a portrait, not only the features, but the air, and expression of the countenance must be imitated, if we would furnish a true representation of the original; for it is by these particulars that one individual is distinguished from another, and not by the general appearance of the body and limbs. For these considerations it is not only allowable but even requisite to give to the human figure, particularly in its height, dimensions greater in proportion to its breadth or thickness, than can be found in any real being. What these dimensions ought to be must be left to the judgment and taste of the artist; for the only rule that can be laid down for his conduct is, to represent his figures of some medium proportions, between those of the real persons he attempts to represent, or even of the finest real human figures, and the dimensions of the celestial or other imaginary figures conveyed down to us from the artists of antiquity. Of the proportional dimensions of the two master-pieces of antient sculpture, the Apollo of Belvidere and the Venus of Medicis, the following is a general specification. These measures are taken in *heads*, each containing 4 *parts*, and each part divided into 12 *minutes*.

	Apollo			Venus		
	H.	P.	M	H.	P.	M
From the top of the head to the bottom of the chin	1			1		
——chin to top of sternum or breast-bone		1	7		1	8
——sternum to pit of the stomach		3	10		3	6
——stomach to navel		2	10		2	7
——navel to end of trunk		3	6		3	9
Length of head and trunk of the body	3	3	9	3	3	6
From end of trunk to small of the thigh above the patella or knee-pan	1	2	6	1	2	3
——small of thigh to middle of knee		1	9		1	6
——middle of knee to small of leg	1	1	9	1	2	
——top to bottom of ancle		1			1	
——bottom of ancle to bottom of heel			9			9
Lower limbs	3	3	9	3	3	6
Head and trunk	3	3	9	3	3	6
Total length of figures	7	3	6	7	3	
From top of shoulder to the elbow	1	2	3	1	2	3
——elbow to the hand	1	1	2	1		6
——joint of hand to root of middle finger		1	8		1	6
——root to tip of middle finger		1	10		1	7
Arm and hand	3	2	11	3	1	10
Breadth of face at the temples		2	2		2	2
——over the shoulders	2			1	3	8
——of body below arm-pits	1	2	5	1	1	8
————at small of waist	1	1		1		8
——over the haunches	1	1	5	1	2	3
——of thigh at top		3			3	1
————above knee		1	8		2	
——of leg below knee		1	6		1	10
——of calf of leg		2	4		2	3
——above the ancle		1	2		1	2
——of the ancle		1	4		1	3
——of the hand, over roots of fingers		1	7		1	6
——over shoulder blades	1	2		1	1	4
Side view.						
From top of head to shoulder	1	1	8	1	1	6
——shoulder to above the hip	1	3	3	1	1	7

From loins to below the hip
——hip to side of knee
——knee to bottom of heel

Length of figures, as before,

Length of foot

Various mechanical contrivances have been used, to assist beginners in drawing the human figure: such as heads, hands, &c. and even the whole body and limbs, so connected by joints as to be placed in all possible situations and attitudes. These contrivances however, are all liable to disadvantages which must greatly diminish their value. In the first place, the young artist is in danger of imitating a very faulty model; and in placing his figure in certain attitudes, all of which are equally practicable for the machine; he is exposed to the hazard of copying as natural a position, and even a distortion, in which no human being can without convulsive violence be beheld. An artist unacquainted with the form and situation of the several members of the body, of the bones which support them, and of the muscles by which these bones are moved and governed, will never arrive at the great object of his art, which is to convey to the spectator a complete and correct idea and expression of the passions and sentiments of the persons he represents. Expression is the language of nature; and without a knowledge of the form and action of the several parts of the human frame, which serve as the organs to express that language, we shall never be able, either to understand it ourselves, or to interpret it to others. In recommending the study of anatomy however, that is, of the shape, structure, position, and uses of the several parts of the human body, it is not intended to intimate that he should make profound researches and experiments, such as are necessary to qualify the surgeon for the duties of his important profession. It will be sufficient for the artist to examine the skeleton, and the muscles with which it is covered; and of these last, those particular muscles which most frequently appear in the various ordinary actions and motions of the body. For this purpose not only books and plates, but models in plaster may be easily procured and when the pupil has made considerable progress, he may then be in a condition to reap advantage from lectures and discussions on the structure of the real human body. It is nevertheless from frequent and sagacious observation of the appearances of the bones, muscles, and features of mankind, when employed in different bodily exercises, or under the influence of the different passions of the mind, that the artist can, with the greatest certainty and precision, collect the most ample stores of information.

Symmetry or proportion may be best learned from casts or copies of the most valuable remains of antient sculpture. Nature which in the formation of every kind of being, seems to have aimed at perfection, does not appear to have been equally solicitous in the production of individuals. Parts of individuals are frequently seen as beautiful as possible: but a perfect whole has never yet been found. In the master-pieces of antient statuary therefore, we are presented with the productions of admirable practical skill, inspired by the most sublime genius, and governed by the most exquisite taste. In drawing from models cast in plaster of Paris,* great care is necessary to place the figure in a proper position with regard to the light which should always fall down obliquely from above, as the light of the sun does in the day-time. By this measure the same parts will be enlightened or darkened as would happen, were a human figure contemplated in the open air. In this kind of drawing however, as the light is suffered to come down from one point only, the contrast between the light and the dark parts is much more distinctly marked, than in objects exposed to the open day, where although the principal light proceeds immediately from the sun, yet so much light is reflected from all the surrounding atmosphere, that the distinction between the light and shade is not very perceptible. When the model is placed in the most favourable attitude and light, the next important step is to choose that point from which it may be viewed with the best advantage, relatively to the subject of the drawing.

When he has, with laborious perseverance, acquired a facility and command of hand, in drawing the human figure, in every possible attitude and situation, the young draughtsman has still a great deal to do before he can have any just claim to the respectable title of artist. Hitherto his employment has been merely mechanical: but the higher parts of his art, which depend on the manner in which his mind is constituted and furnished, are all still to be acquired.

Light and shade. The management and distribution of the light, so as that those parts of an object which, in any given situation, are exposed to it, may be so represented, while the other parts are darkened, are in many cases merely mechanical operations. If the sun shine obliquely on the corner of a house, we know that one side and an end will be enlightened, while the other side and end will be in the dark; and there is an almost instantaneous transition from the enlightened part of the ground to the darkness of the shadow. Even in representing the light and dark parts, and the shadows of objects of irregular and complicated forms, geometrical rules exist, by which the artist may be guided in his representations. Of these rules and their application to drawings of different

---

* *Plaster of Paris* is so called because it is in great use in that city, being dug up in great quantities in a hill called *Montmartre*, which hangs immediately over its northern side. This substance is called *Gypsum, Selenite*, or *Alabaster*; and it is a combination of lime with vitriolic acid, or oil of vitriol. When this substance is exposed to heat, it falls down into a very white powder, which when mixed with water unites with it very rapidly, and in a short time becomes quite solid. From this property it is used for taking copies of figures, by casting in a mould while liquid: and the figures thus produced are for this reason called casts.

Carrying

London, Published by T. Kinnersley Oct.r 1.st 1814.

sorts, excellent illustrations will be found in various works, particularly in *Nicholson's Principles of Architecture.* When the terms light and shade, however, are applied to drawing and painting, something more is understood, in which these geometrical and mechanical rules must be combined with solid judgment and refined taste. Directions in this part of drawing must therefore be of a very general and comprehensive nature. When the pupil is in some measure master of tracing the outline or shape of an object, he will begin to complete the work, by distributing the lights, by what is called *shading.* In drawing upon paper the natural colour of the substance is sufficiently white and bright to represent the strongest light that can fall upon it: but this brightness may be still greatly augmented by contrasting it with black colouring, more or less deep, in proportion as the parts are more or less remote from the light, whether direct or reflected. In the first place the artist considers from what point, and in what direction the rays of light fall upon the object to be drawn: for from that point as a centre, all the light must appear to the spectator to proceed. That part on which the light falls most directly must be the brightest in the drawing, and that diametrically opposite must appear the darkest; the intermediate parts gradually diminishing in brightness, as they retire from the direct light. This is particularly observable in regular round surfaces, such as a thick column, a round tower, &c. when exposed to the sun's rays. A ray of light proceeding from the sun, or any other luminous body, and just touching the side of a column, or other solid substance, ought to proceed forward in the same direction. This however, we know not to be the case: for the particles of light being attracted by the matter of the column, the ray will be bent inwards towards the column, by which a quantity of light will be thrown in upon parts wholly hidden from the body of the sun. The consequence of this is, that the passage from light to dark is much more gradual, and much less sudden than, in other circumstances, would happen. This gradual diminution of brightness requires therefore a sensible space on the picture, proportioned to the diameter of the circular surface on which it is represented; and it is chiefly by the judicious and correct proportioning of gradations of colour, that the spectator is enabled to comprehend the nature and form of the substance presented to his view. This however is not all: in drawing and painting we are not to consider only the state of objects as they really are, with respect to the light, but as they affect our eye. When I converse with a friend in the open air, all parts of his body being equally distant from the sun, they must, when turned towards him, be all equally illuminated. To me however, they do not appear to be so: his head seems to receive a greater portion of light than his shoulders and arms, and these still more than his legs, while his feet, as the most remote from my eye, appear the darkest of all. From these observations the artist learns in what proportions to bestow his darkening shades; and in this process, critical experience and observation must be his only guides. It is also with a reference to the nature of our sight that objects at a

distance appear less bright than those near to the spectator. The rays of light proceeding either originally or by reflection from any object, resemble the radii proceeding from the centre of a circle. If therefore we be so near the object that a great number of rays must enter our eye, the object will appear much brighter than if we had beheld it from a considerable distance, where the rays of light, spreading out or diverging in all directions, must be widely separated from one another, and consequently a very small number can enter our eye. From this apparent darkness of distant objects arises their indistinctness: at a distance of a few score yards we can recognize the features of an acquaintance; but if the distance between us be much enlarged, we can scarcely determine whether the figure be that of a human being. If now we examine the same figure through a perspective glass or telescope, the machine according to its powers will collect a greater or less number of rays proceeding from the object, which will be united in the eye; the figure will consequently become distinctly perceptible, and will, by a natural process of the mind, seem to be brought to a position so near to us, as that it would be equally distinct and perceptible, if beheld only with the unassisted eye. It is therefore by the brightness, and consequent distinctness of objects, that we judge of distances: this judgment however must be acquired, it is not instinctive, nor born with us. The infant in the nurse's arms, struggles to catch at the candle or at the moon apparently alike within its reach: the young man whose eyes were opened by the celebrated surgeon Chesselden, when light and external objects first broke in upon him, imagined every thing he saw to be equally remote, or rather equally near: for referring the operations of the sense of sight to those of feeling, he said every thing touched his eye. This being the case, the nature and effects, the disposition and management of light and shade, are to be understood only by a careful and judicious observation of objects, as they appear in all varieties of circumstances in nature: the only substitute for this personal observation is, an intelligent imitation of the productions of those artists, whose reputation for excellence, in this most important part of their profession, is established on their real merits.

Drapery. The human figure no where presents straight lines, or geometrical curves: its varying and flowing forms however, may be considered in general as parts of circular sweeps: the gradations from light to dark may therefore be conducted on this idea. When drapery or garments of any sort are introduced, the artist has not the same resource. The drapery shown by the antient sculptors, particularly in statues of females, is often so full of minute and complicated folds, and seems to apply so closely to all the protuberances and depressions of the figure, that unless they actually copied from fine linen just taken out of the brook, we can conceive no kind of stuff of which their drapery could consist. This supposition is however probably very ill-founded: but at any rate no dry stuffs with which we are acquainted, would naturally fall into similar forms. In clothing figures in drawing, several things are to be considered: 1. The eye must never be in

doubt about the part or limb supposed to be covered by the drapery, which ought still to be, in some measure perceptible. To secure accuracy in this point, it will be adviseable for the beginner first to sketch a correct outline of the figure, and then to apply the drapery. 2. The clothing must not appear to sit too closely, but to flow round the figure, which will then seem to be at liberty to move with ease and grace. Custom can make us endure, nay fashion and affectation may even bring us to admire the ever-varying dress and drapery of Europe: to compel the artist of taste however, to draw, or paint, or carve, a human figure, in such habiliments, is to convert his art, which would be his delight, into his torture. We accordingly find that, when such adherence to present usage is required, as in portrait-painting, the artist of taste has employed his genius, in giving to the modern dress as much of an air of ease and freedom, as can consist with the truth of his work. We smile at what we style the stiff, formal, cumbersome, unnatural clothing of old portraits, in a country-gallery: but we forget that, in the revolution of years, the dress the most admired in modern times, for ease, freedom, conveniency, and suitableness to the human body, may deserve the same description from posterity. If such mistakes be committed in modern painting, what will be thought of similar errors in sculpture, of which the productions ought to be destined for perpetuity? The time was when the man of taste could be amused, by the exhibition of an illustrious commander, with cocked hat, clumsy uniform, and jack-boots, on horse-back, in one of the principal squares of London. He could be amused at this spectacle because, having been erected by an obscure individual, it could not justly be considered to reflect on the national taste and judgment; and because the ridicule it deserved seemed to warrant that it would ever remain without a rival. Later times however, have taught us better things: we now see on monuments of public respect to meritorious servants of the public, erected at the public expense, commanders by sea and land, exhibited as if they had been instantaneously converted into marble, while composedly standing on the parade, or the quarter deck.——But to return.—3. The great folds of drapery should be first drawn, and then broken into the smaller; taking care that the breaks and crossings come as near as possible to the effects of real garments. Folds in general should be as large as may suit the nature of the stuff, and consequently few in number: but in applying this rule, regard must be paid to the office, situation in life, and character of the individual represented. The dress of an antient philosopher, of a magistrate, or person of personal or official dignity, ought to be ample and flowing; that of a courtier, light, easy, and airy; that of a peasant, sober, plain, and merely what is necessary for raiment. 4. The dress must be adapted to the body, shewing, by the small size of the folds upon the joints, that it is suited to all the variety of motions, which different actions and attitudes require; and also by its general disposition, that it is, or can be affected by the wind. 5. In the application of jewels, lace, and other ornaments

the young artist should remember the observation of the great painter of old, to the pupil who, in a piece intended to represent Helen, the fairest of Grecian women, loaded his figure with jewels, "Young man! unable to make her beautiful and lovely, you have determined to make her rich and fine." It is not meant to insinuate that the introduction of extraneous ornaments may not be exceedingly proper, on certain occasions; and that the artist who can introduce them with judgment and taste, and represent them with skill, is not entitled to commendation. All that is here intended is, to impress on the pupil this truth that, in drawing or painting, as in morals, in literary composition, and in mechanical operations, simplicity is a never-failing source of pleasure to the observer, and a certain evidence of superior genius in the artist.

In shading drapery the pupil is to consider carefully the nature of the folds: if they be produced by the swelling projections of the body, they will in general be round and regularly full; and must of course be gradually darkened. But it more frequently happens, in loose full drapery, that the stuff is suddenly bent out or in, with a sharp angle; in which case the change from the light parts to the dark must be instantaneous, in the same way as the dark end of a house is distinguished from the bright front enlightened by the sun. The application of this rule to particular cases must depend on the experience and skill of the artist: and every hour of the day experience on the subject is at his command. Shadows in drawing are usually formed by parallel lines, curved or straight according to the situation, done with black-lead: those are again crossed by others where the darkness is greatest, and softened by more delicate strokes where necessary. Cross lines ought neither to lie at right-angles on one another, nor in a direction nearly coinciding with the original lines: there is a just medium of inclination which, by observation of skilful drawings, will be easily acquired: it may however be remarked, that the less crossing of lines in drawings the better will be the effect. Sometimes the shadows are rubbed in, and their edges softened with a *stump* (a piece of soft leather tightly rolled up,) a mode very expeditious, and of good effect. This however, should be done with discretion, and it is better to form the shadows by soft lines, in a clear regular way. In copying, the student should always prefer drawings to engravings done in lines; because by these last he may be drawn on to acquire a hard dry mode of execution. He must particularly avoid copying with a pen all the lines in engravings, used for the shadows. Many works of this sort have been executed, at a prodigious expense of time and application, and have been thought wonderful by persons of little skill: but artists and other judges always consider these productions as really of no value, and lament to see so much assiduity and labour so uselessly applied. In copper-plate engravings, the only way of producing shadows is by lines; or at least with a proper effect: but in drawing, which is a very different process, the same necessity for lines does not exist. In general it may be observed that in drawing, as in other operations, the less that labour is apparent,

DRAWING

Expression by Action.

London Published by T. Kinnersley Oct 1 1814

the better will be the effect; and that though all possible pains must be taken, to make drawings and paintings as perfect as possible, yet this labour should be concealed as much as can be done; that the whole may appear to be not only well executed, but executed with the greatest facility.

In learning to draw it is of more importance than is commonly supposed to imitate only the finest productions. The mere act of copying is the same whether the pupil be employed on a good or a bad original; at the same time that a model of middling merit is really the most dangerous. Bad models will strike and disgust him: but those that although not good, are in a state of mediocrity, will deceive his want of skill, and he may be wasting his time and attention on models which, as they do not appear to be really bad, he may conceive to be really good.

In drawing human figures or faces, the most essential object is to acquire the art of giving expression to the countenance, and general attitudes of the body. The various passions, affections, sentiments and emotions, by which the human frame is agitated or influenced, must of necessity be expressed in the picture, if we would give life, character, and even resemblance to the person we endeavour to represent. The language of discourse is various and different, in the different regions of the earth; but the language of the natural passions and sentiments of the mind, is in a great degree the same, in every quarter of the globe. In this language of nature the countenance, and in the countenance the eyes, are the chief organs of expression. In a portrait, a statue, in the living figure of a stranger, a man of note in the world, we are eager to peruse, as it were the book of the countenance: in our intercourse with men and friends, it is in the eye we endeavour to read and understand the secret workings of esteem or dislike, the swellings of affection, or the ranklings of vengeance. To gain some practical proficiency therefore, in this universal language of nature, is indispensably necessary in the painter, as well as in the member of society. On the subject of the passions and their outward expression much has been written, by men of ingenuity and observation; and with a view to the assistance of the young artist, a set of heads has been repeatedly published from original designs of *Le Brun*, a very eminent French painter in the end of the 17th century. The countenances there given, as of persons under the dominion of love, hatred, hope, fear, joy, grief, &c. are in some degree over-charged with expression: but for this good reasons might perhaps be devised. In the first place, in order to strike the imagination of the young artist and make a lasting impression on his memory, it is absolutely necessary that the images set before him should go to the utmost bounds of characteristic expression: for after all, the impression on his mind, will not unfrequently fall far short of that which ought to be made. In the next place those images were drawn in France, where the language of gesture and countenance is uttered in much more impressive tones, than with us in these countries. In the warmer

gions of Spain and Italy, the natural language of some passions d emotions is so strongly pronounced that, while to a Briton it ems to run into the greatest extravagance, among the ardent ns of these burning climes a volatile Frenchman will appear ore cold and phlegmatic than the gravest Briton does in ance.

To assist the pupil in drawing the human countenance and gure, at the same time that he studies the images of the passions, given by *Le Brun*, and in many later works, it will be of service lay before him the following short but distinct description of the ssions and their causes, drawn from the writings of the excellent r. *Isaac Watts*. An object suited to excite the passions must ive one or more of these three properties: it must be either rare and uncommon, or 2. good and agreeable, or 3. evil and sagreeable; or at least we must have some such idea or apehension concerning it. The chief passions of our nature may so be classed under three heads. Under the 1st are *admiration*, *ve, hatred*. If the object be rare or uncommon it excites adiration; if good or agreeable it creates love; but if evil or sagreeable it moves our hatred. The 2nd class contains the rious degress of love and hatred adapted to the several objects. an object be valuable, it excites our esteem; if worthless, we gard it with contempt; if it be such as to be susceptible of od from us, we feel benevolence or good-will towards it: if on e contrary it be fit to receive evil from us, the hatred is called alevolence or ill-will. An object that appears pleasing or fit to us good, raises in us complacency or delight: but when it pears displeasing and unfit to do us good, we regard it with slike and aversion. The 3rd class comprehends those passions hich arise from complacency and dislike. In these the pleasing ject is more properly called good, and the displeasing object il, than in the other passions. If the good be absent or unssessed, but still possible to be obtained, the passion of love ows up to desire; if the evil may possibly come upon us, the tred shows itself in aversion and avoidance: aversion is even lt for evils to which we are in no way exposed. When there is a ospect of obtaining the absent good, hope springs up in the ind: but if the evil be likely to fall upon us, it fills us with fear d dread. But fear also arises from a present or expected good, danger of being lost; and we feel a hope of security from some sent but threatening evil, or of deliverance from evil that is esent. If the good be actually obtained, or the evil prevented, e are filled with joy and gladness; when however, the good is tually lost, or the evil is really come upon us, it overwhelms us ith sorrow and grief. The person who helps us in the attainment good, or the prevention of evil, calls forth our gratitude: but who hinders our attainment of good, or brings evil upon us, ises our anger. To some or other of those general heads may referred the greatest part, perhaps the whole of the passions hich agitate or animate the heart of man.

LANDSCAPES.

Whoever wishes to make any progress in landscape-drawing must absolutely study the principles of perspective. Without this knowledge he may certainly acquire a facility in copying drawings, paintings, or engravings, placed before him: but if ever he attempt to compose a scene from his own imagination, or even to copy after nature, he will be every instant in danger of falling into errors the most egregious and ridiculous. Persons entirely destitute of a musical ear have certainly learned to dance, in time and measure, by a mechanical imitation of other performers. Instances are not wanting of blind men, who have attained the wonderful faculty of even instructing their seeing fellow-creatures, in the knowledge and uses of light and colours. These however, are extreme cases; and instead of being cited, in apology for wilful ignorance of necessary qualifications, they ought to stimulate the more favoured pupil to his utmost exertions, when he considers what progress the above persons have, by dint of industry and application, been able to make, in spite of all their natural disadvantages. "There is one precept," said Sir Joshua Reynolds, "in which I shall be opposed only by the vain, the ignorant, and the idle. I am not afraid that I shall repeat it too often. You must have no dependance on your own genius. If you have great talents, industry will improve them: if you have moderate abilities, industry will in a great measure supply their deficiency. Nothing is denied to well-directed labour: nothing is to be obtained without it. I will venture to assert that assiduity unabated by difficulties, and a disposition eagerly directed to the object of its pursuit, will produce effects similar to those which some call the result of natural powers." The young draughtsman therefore who refuses to acquire a competent knowledge of the principles of geometry, and of their application in perspective to the representation of rural scenery, sets up his own conceit in opposition to the professional counsels of one of the most expert and scientific artists whom modern times have produced. By perspective he will be enabled, not only to understand and draw all the parts of a building, often a principal feature in landscape, but also to form an accurate conception of the manner of representing the distances of objects, their regular diminution in size and distinctness, in proportion to those distances, the windings of rivers and roads, and properly to place every object, so as to produce the effect intended by his work. The next step is to copy good drawings; taking particular care that his very first labours be employed on the best examples he can procure. Nothing can be more absurd than the persuasion that any sort of models, however indifferent, will do well enough to begin with, or as it is termed, *to bring in the hand*: copying from such models is more likely *to put it irrecoverably out.* In choosing drawings to serve as models to be copied, those should be preferred where the outlines are correctly and distinctly drawn, rather than others, which although less accurate, may be intended

merely to produce a good effect. The first thing to be studied, as the pupil must understand, is to be able to express, with the black-lead pencil, the forms of all sorts of figures and objects, with accuracy and fidelity: until some proficiency in this be acquired, no attempt should be made to produce a finished drawing. By inattention to this important circumstance, many young artists, led away by the bewitching notion of executing a piece of striking effect, (which may be attained in the judgment of the ignorant multitude, without due attention to the correct principles of drawing,) have fallen into false and erroneous methods, from which they have never been able to recover themselves; and their natural abilities have been wholly prevented and lost.

Black-lead is the most useful material for drawing the outlines of landscapes, which should not be afterwards gone over with the pen and ink: for unless it be very well done, the ink strokes will give an air of harshness to the work. Indian-ink alone should be used for the shadows, until the student be well advanced, when he may begin to employ colours. This restraint may appear severe: but the practice of making coloured drawings at an early period is highly injurious to future progress. The work pleases the eye, and draws on the artist the applause of the unskilful, and the disingenuous. Satisfied with this reward, we need not wonder if he halt at this point of his career, and never afterwards exert his faculties, to gain the truly encouraging commendations of persons of genuine skill and taste. The first thing to be learned is to imitate forms correctly, next the manner of shading objects as they are in nature, then adding the general light and shade of the piece. All these operations are best performed by using black-lead, black-chalk, white-chalk, Indian-ink, either separately or combined as may be best; renouncing all thought of employing colours, in imitation of those objects in nature, until considerable proficiency in the management of the former substances shall be acquired. When various colours are employed, the perfect resemblance to the original objects, which they *seem* to produce, is doubtless very seducing for the inexperienced observer, and even for the student himself. That this resemblance however is only *apparent*, will be evident to any one who shall compare the appearances of objects in the natural landscape, in the various changes of the light, and of the weather. To treat at some length of the nature of colours, will be the business of the ensuing part of this work relative to *Optics* or vision: in this place however, it may be proper to make a few remarks on the nature and effects of light, in so far as they modify the external appearance of objects. Let a room having a southern window be made as dark as possible: in the window-shutter make a small hole, through which a ray of the sun's light may enter: in this ray place a *prism* (a solid triangular piece) of crystal or clear glass. The rays of light, in passing out of the air, into and through the glass, and again into the air, are bent or refracted in different angles, according to their component parts: if the ray of light after passing through the prism be received upon a sheet of white paper, or the white wall, it will

DRAWING.

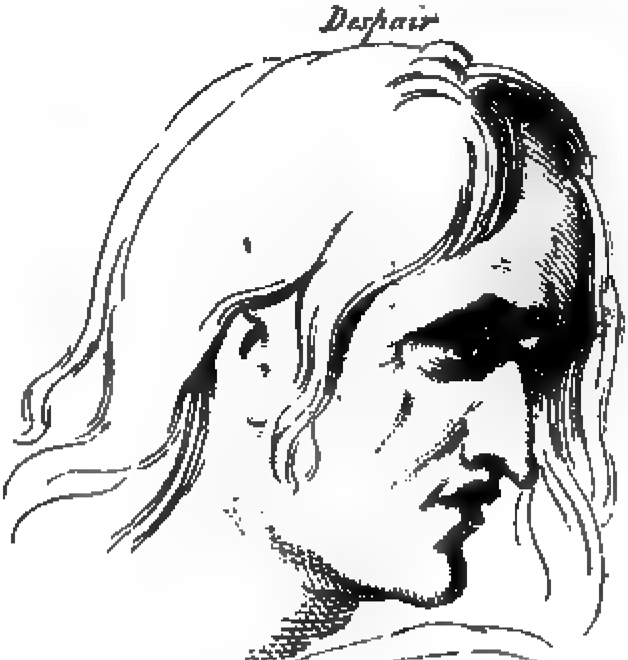
Expression by Features.

Joy

Greif

Laughter

Despair



Hope

Charity

Published by T. K[illegible]ley Feb. [illegible] 1805

exhibit, not a bright light, as when it entered the room, but the seven separate colours, *red*, *orange*, *yellow*, *green*, *blue*, *indigo colour*, and *violet*. The figure on the paper will be a long oval; and if it be divided into 360 equal parts, the red will occupy 45 of them, the orange 27, the yellow 48, the green 60, the blue 60, the indigo 40, and the violet 80. Thus we see that a ray of light, which to us appears white, is really composed of seven colours. Hence proceed the beauties of the rainbow; and hence, if we could procure powders of the finest quality, precisely of the several colours and proportions above mentioned, and mix them most intimately together, the mixture would be white, the opposite to which black would express the absence or privation of all colour. This last expression however, is only true within certain limits. A ray of the sun's light, received on a piece of clear glass of equal thickness, passes through it and appears on the other side of the same colour and brightness as before it entered the glass. If on the side of this glass opposite to the sun, a mixture of tin and mercury (commonly called silvering) be applied, the ray of light, instead of passing through these substances, will be reflected towards the sun, of precisely the same colour as before. It was however before observed, that a ray of light passing through a triangular piece of glass, did not preserve its original colour on the other side, but was separated into seven different tints, of which none even approached to its original white. From this fact it is natural to conclude, that the different colours we behold in substances are produced by some peculiarity in their parts and structure, by which each is disposed to reflect that particular part of light, by which we are authorised to conceive it to be of a certain colour. Thus the component parts of grass, uniformly reflecting the green portion of the sun's rays, we naturally say grass is green, &c. That light is necessary to the production of colour is confirmed by every day's experience. Onions, potatoes, &c. will shoot out roots and leaves, in a cellar where no light can enter: but these shoots will be white. If in this state the plants be brought up and exposed to the sun, the whiteness will soon go off, and the natural colour of each will be produced. When a gardener wishes to *blanch* his cabbages, celery, &c. he ties or covers them so as completely to exclude the sun's light: the parts thus concealed are white, as is expressed by the French term *blanchir*, which signifies to whiten. That colour is nothing really inherent in bodies, but a modification of light, may be shown by numberless experiments: nor does that colour always appear the same to our eye. The grass of the field and the trees of the mountain are green: but if these objects be beheld from a distance, or in a gloomy sunless day, their verdure and varying shades are all confounded in one leaden tinge. The sky, we say, is light blue; and so it is in our climates: in the purer atmosphere of the south of Europe, its complexion approaches to indigo; and on the snowy summit of *Mont Blanc*, the sovereign of the Alps, nearly three miles above the sea, and far above the usual region of clouds and vapours, from the extreme purity of the air, and the contrast of

attitudes, show that they all receive the wind in a similar direction.

In representing clouds the nearest must be in the upper part of the picture, passing as it were, over the head of the draughtsman and the spectator; they must also be the most strongly marked and shaded: but as they are more and more remote, they fall lower in the picture, until those over the distant mountains mingle and disappear in the horizon. The appearances of water in drawing are exceedingly various: when calm and unruffled, it strongly reflects the light, and having then no depressions or elevations, it can possess no shades, excepting what may be projected upon it from trees, boats, animals, buildings, &c. on its banks. When violently agitated, water is broken into deep hollow shades, imitating waves; and when dashed against rocks, ships, &c. strong contrasts of black and white are introduced expressing its foaming surges. As water thus violently agitated by the winds is incessantly changing its appearance; or when thrown headlong down a lofty rugged precipice, it is wrapped up in foam and vapour, we need not wonder if representations of the sea and rivers, in such cases, so rarely come near the truth.

Opinions are divided on the question, what ought to be the horizontal extent, from right to left, of the scene comprehended in a landscape. All that can be determined on this point seems to be that, when the spectator has taken the proper point of view of the picture, he should never be under any necessity of turning his head from the one side to the other. A discourse from the pulpit may be separated into a number of principal and subordinate divisions, each of which contributes its share to the establishment or the illustration of the one important truth which it is the purpose of the preacher to enforce. A heroic poem, the Iliad of Homer, the Æneid of Virgil, the Paradise Lost of Milton, for example, introduces to our acquaintance personages of great variety of character, and interests us by the recital of a great variety of incidents and adventures, in which those persons are involved: but all these personages and all their adventures serve (or ought to serve) only to forward, and carry to the destined termination, the grand object of the poem. Just the same should it be in landscape, and in historical painting. The main purpose of the artist should be to present to the spectator one principal and interesting object, scene, or action: but every collateral object bearing a natural and obvious connection with the principal, and tending by that relation or by contrast to heighten the importance and beauty of the principal, ought certainly to be introduced. If this assertion be admitted it will follow, that the scene or space within the bounds of a picture, ought to be very limited with relation to its effect on a spectator. In a case of this sort, no precise measures or dimensions can possibly be laid down: but there may be much propriety in adhering to the advice, that the length of the picture from right to left, should never exceed, in some cases not equal, the distance of the spectator from the centre of the view.

Panorama. Some thirty years ago, the world was, for the first time, entertained by an exhibition, in which the effect of the principles of perspective in landscape, was brought as near to a real ocular view of the objects represented, as can perhaps ever be accomplished. The situation of *Edinburgh*, the metropolis of Scotland, is singularly romantic. Occupying the ridges and slopes of eminences, and the intervening hollows, it is in some quarters commanded by lofty overhanging precipices, the whole crowned by the volcanic peak of *Arthur's Seat*, springing up to a height of upwards of 800 feet. On the north of the highest ridge on which the town is built, but in a central situation with respect to the population, stands *Calton Hill*, rising to the height of 300 feet, and in many parts enclosed by rocky precipices. The central situation of this eminence, joined to its elevation, naturally points it out as a proper station, for obtaining a satisfactory view of the city and the surrounding country: and nothing can be more striking than the contrast between the objects presented to the eye, on the different sides of the station. On the south is seen the antique grandeur of the old city, terminated at one end by its castle, perched on the summit of a precipitous rock, and at the other by overhanging cliffs; while the back ground is filled by the lofty range of the Pentland hills. Turning now towards the north, the spectator discovers a scene of a description totally different. On one hand he commands the spacious and handsome steets and squares of the new city, while before him spreads a richly cultivated plain, studded with villages and villas, the town and crowded port of *Leith*, on the shore of the Forth a noble arm of the sea, extending to right and left, beyond the reach of the eye; its surface diversified by islands, and continually enlivened by shipping, and bounded on the opposite shore by the uncommonly populous and productive county of Fife: in the distant horizon appear the Highland mountains 60 and 80 miles off. Struck with the extraordinary nature of these prospects, and with the fitness of Calton Hill, as a point from which drawings of them might be made, an ingenious artist *Mr. Barker*, divided the circumference of his horizon into a number of equal portions, of each of which he made drawings in succession. Placing the pictures erect round his study, to see how far they corresponded with the original scenery, it fortunately occurred to him, that a series of landscapes (or rather one continued range of landscape) on a large scale, placed in an erect position, and forming a complete circle, would to a spectator, standing on a central position, representing that from which the circle of views had been drawn, convey the image of the original objects, with far greater accuracy, than could be done by any number of detached views, each circumscribed by its own particular border and frame. Maturing this happy thought to perfection, Mr. Barker, after some time, constructed in the vicinity of Leicester square in London, an amphitheatre in which circular representations of Edinburgh and the environs, and of many other interesting places, scenes, and exploits, have been exhibited. The interior of the edifice is circular, and all around

is suspended the picture, on a scale adapted to the radius of the room, in the centre of which, or sufficiently near it, the spectators have their station. The light descends from above, quite round the theatre: but it is so concealed by very ingenious contrivances, as are also the upper and lower edges of the picture, that if the spectator will but have the patience to wait, until his eye be accustomed to the quality of the light, and to the fascinating effect of perspective drawing and colouring, it will be impossible for him not to imagine himself to be actually in the midst of the scenery presented to his view. This amphitheatrical exhibition, admirable no less for its simplicity than for its truth, is justly named a *panorama*, from two Greek terms, signifying a view all around and in every direction, of all objects within the reach of the eye.

In giving this minute account of the greatest improvement in landscape-painting, as far as the truth and the effect of the representation are concerned, of which it seems to be susceptible; the young artist will see something more to be intended, than merely to give him a notion of the origin and nature of a species of picture, accounts of which he may have heard, and specimens of which he may have examined. The most useful discoveries are likewise the most simple; so much so that when they are made known, it is a matter of wonder that they were not sooner noticed. In the course of the studies and labours of the young artist, in his room and in the field, many notions may present themselves to the ingenious fancy. To such natural suggestions he ought if he possess any genius and knowledge, particularly to attend; for to such are mankind indebted, for the high state of perfection, to which many arts and sciences are now carried. To say that a man will sit down to invent is absurd: he may, nay, he must learn and observe; and the results of his learning and observations will be the materials, by the combination of which new facts and new appearances will be presented to his mind. This is the process which in strictness deserves the name of invention: but he who has laid up no materials can form no combinations; for it is an indisputed maxim, in human affairs, *de nihilo nihil fit*; that is, *from nothing nothing can come*.

Copying of drawings, &c. Persons little accustomed to draw, may be desirous, or find it necessary to take a copy of a drawing or an engraving; for doing this various mechanical operations have been contrived, of which the following are the most convenient. These methods are undoubtedly useful even to expert draughtsmen and engravers, when great expedition or minute accuracy are required: but they ought never to be employed by a student of the art of drawing. *Tracing against the light.* Place the original on the pane of a window, and the paper, on which the copy is to be made, upon it: from the light of the window the several lines of the original will be seen, which must be traced with a pen and ink, or rather a black-lead pencil. This method however, is fit only for small works, besides that the attitude of the drawer is inconvenient: the better way therefore is, to have a large plate of glass fitted in a frame, in such a way that it may

be placed in any proper inclination, like a dressing-glass or a music-stand. Upon the glass is laid the original, and on it the copying-paper; and by means of a candle or lamp placed behind the glass the lines of the original may be commodiously taken off. The same instrument may be used in good steady daylight. The reader will be aware that the paper employed in these operations must be particularly clear and transparent, that the finest lines of the original may be copied. The material adapted to this purpose is hence called *tracing-paper* (from the French *tracer* to draw,) which is commonly prepared in this way. Mix together equal quantities of oil of turpentine (the distilled juice of the wild pine tree) and drying-oil (a mixture of linseed oil and litharge, or sugar of lead;) and with a soft rag rub the mixture evenly over fan, or tissue, or any other sort of thin paper of a fine grain. Hang the paper up to dry, for a day or two, when it will be fit for use. If paper thus prepared be laid upon the drawing or print you wish to copy, you will see every line distinctly, and may then trace them over with the pencil. When it is wished to trace with ink, mix in it a little ox-gall, by which it will take to the paper, which it would not otherwise do, on account of the oil.

Camp-paper is another preparation employed in drawing. Take some hard soap, and mix it up with lamp-black and water, to the consistence of jelly: with this substance brush over one side of a piece of paper, and let it dry. In using it, put it between two sheets of clean paper, the black side downwards: then with a strong pin, or a piece of stick sharp-pointed, draw or write what you choose upon the clean paper. Wherever the tracer has touched, an impression will be made on the undermost paper; and this impression may be made of any other colour instead of black, by mixing the soap with powder of the desired colour.

Stenciling is performed in this way. Lay the print or drawing to be copied, on a sheet of paper; and with a pin or needle prick all along the outlines with a multitude of holes, through both papers. Then lay the clean paper with the holes upon the paper on which the drawing is to be made, and dust it over with charcoal finely powdered in a small muslin bag; when the dust will pass through the holes, and shew a correct representation of the original figures. This paper with the holes may serve for any number of copies; and is very useful for ladies who work flowers or other ornaments upon muslin.

Enlarging or contracting drawings, &c. These operations are performed in different ways; but most commonly by means of squares or other regular figures, drawn on the original and the paper to which the copy is to be transferred. To do this divide the sides of the original into any convenient number of equal parts, the more the better, and with a black-lead pencil and a ruler draw lines across the piece, in both directions. Then divide the sides of the paper on which you are to draw, into the same number of equal parts, to be joined by cross pencil lines; by which means it will be divided into the same number of squares as the original. If the copy is to be an enlargement of the original,

the equal parts must of course be greater than those on the original; but if the copy is to be a contraction, then the parts must be less. The original being placed before you, copy into each square the parts contained in each square of the original; carefully observing to place every part in a situation exactly corresponding to that in the piece before you. To prevent the necessity of drawing lead lines on the original, which may sometimes be injurious, take a large pane of thin glass, and divide its sides into a number of equal parts, to be joined together by cross lines, drawn with lamp-black ground down with gum-water. This glass thus divided into squares is laid over the original, and the copy is made agreeably to the objects as seen directly through it.

The *Pantagraph* is an instrument composed of rulers combined together, by which one may copy, enlarge, or diminish the outlines of any print, drawing, plan, map, &c.

Camera obscura. By this Latin name, signifying a *dark chamber*, is understood a method of employing certain properties of light, within a room, a box, &c. to give a representation of external objects. The rays of light reflected from objects convey to our eyes impressions of their form and colour; and if those rays can be admitted into a chamber, where no other light can enter, the same forms and colours may be distinctly perceived in it, on the wall or some other substance proper to receive and exhibit their appearance: hence the nature and the name of the *camera obscura*. Whoever has been in a room with the window-shutters closed, and the sun shining bright on the objects in the street, must have observed, upon the wall or the roof, shadows and bodies of light, moving in different directions, according as the men, horses, carriages, &c. moved in the contrary directions. These shadows are produced by the light reflected from the moving objects in the street, and entering the room through some hole or chink in the window-shutters. Choose now a room having a northern aspect, and a view of a street, a road, or any other scene consisting of objects in motion as well as stationary, on which the sun may shine with full force. Let the room be darkened so completely that no light may enter it, excepting through a small aperture made in the shutter. In this aperture fix a *lens* convex on both sides; that is, a circular piece of pure glass or crystal, thin at the edges, and swelling out regularly on both sides to the middle, such as a magnifying, reading, or common spectacle glass. The rays reflected from the objects on the outside, passing through the glass, will be collected in a focus within the room, where if a sheet of paper or other white surface be placed, a representation of those objects will be exhibited, more bright and distinct, with the lights and shades more perfect than in the original objects themselves; because the whole number of rays from large surfaces are collected and projected into a much smaller space. Such is the nature of the *camera obscura*: but for the use of the landscape-drawer a machine must be provided, which he can transport from place to place, to supply him with images of scenes proper for his pencil. In the side of a square box, of a convenient portable size, is fixed

a tube, and in it a convex lens, which, by drawing out or pushing in the tube, may be placed so as to give the most distinct image of the external scene. Within the box, opposite to the lens, is fixed a plain mirror, leaning backwards at an angle of 45 degrees; so that the rays falling on it from the lens will be reflected perpendicularly upwards to the top of the box; which being only covered with oiled paper or a plate of glass, the images may be traced with a pencil, and afterwards transferred to the proper drawing-paper.

Transparent drawings. This species of drawing, in which the effect is produced by light passing through the piece, is no new invention; but it has of late years come much into vogue, for ornamenting the interior of our apartments, as well as the exterior of public edifices, on occasions of splendid rejoicing. These transparencies, when judiciously managed, have a very agreeable effect, especially in scenes where moon-light, fires, explosions, &c. are represented, in which brilliancy of light, and strongly marked shades, are peculiarly requisite. In former times windows in private mansions, as well as in churches, were adorned with stained glass: but the great expence of such ornaments in these days, and the risk of their being accidentally destroyed, have nearly precluded their use in common chambers: hence transparent drawings and paintings have been substituted in their place, which may be procured at a very small expense.

The paper on which the transparent figures or scenes are to be drawn, is fixed and strained out on a frame; that it may be held up to the light, in the course of execution, to see the progress of the work. When the outlines are traced, and the colours and tints laid on, in the common way of coloured drawings, the picture is placed against the window, on a plate of glass, framed for the purpose. Then the shadows are deepened with Indian-ink, or with colours, as may be necessary; laying the colours, in some cases, on both sides of the paper, to give them the greater depth and force. The concluding touches on the shadows and outlines are done with ivory-black or lamp-black mixed up with gum-water. When the picture is finished, every part being in its proper point of colour and brilliancy, all those parts which are to be the brightest, such as the body of the moon, and fires, are very carefully touched over with spirits of turpentine; and those parts requiring less brightness, on one side only. Then lay on immediately with a pencil, a varnish made by dissolving one ounce of Canada balsam (the rosin of the Canadian pine-tree) in an equal quantity of spirit of turpentine: taking great care in the application, as this varnish is apt to spread. When the varnish is dry, the parts representing flame, are tinted with red-lead and gamboge, slightly tinging the smoke next to the flame: the moon must not be tinged with any colour.

In this kind of drawing much of the effect depends on the choice of the subject. The half-ruined Gothic cathedral or castle, whose antique towers and pointed pinnacles, with their dark colours, finely contrast with the brilliant but pale light and body of the moon. Rays of light breaking through ruined windows, half

choaked up by ivy;—fires blazing on the ground, amid the clustered pillars and mutilated tombs, and darting a strong light on the haggard countenances of a band of robbers:—a building or a ship on fire;—such are some of the objects to which transparencies are peculiarly adapted, and the effect of which can in no other way be so strikingly represented. For the management of these drawings no particular rules can be laid down; farther than that the fine lights should not be brought very near the moon, whose pale silver light would be injured by their glare, and that those parts of the design which possess no particular interest, should be kept in impenetrable gloom, while in the principal light the parts should be marked with great precision.

Mechanical drawing. This branch of drawing is employed in the representation of buildings, fortifications, machines, and other regular objects, in which truth and accuracy alone are required, and the productions of fancy and embellishment are wholly inadmissible. Plans, elevations, and sections of such objects are constructed on the principles of geometry: but in views perspective must be called in. Mechanical drawing is to be considered rather as an useful than an ornamental qualification; and proficiency in it ought to be more highly valued than it is in general. All should be acquainted with its principles, just as all should learn to write. Every one must be sensible how imperfect and unsatisfactory are mere descriptions of towns, buildings, machinery, and other similar objects; whereas by plans, elevations, sections and views, not only a distinct conception of the objects may be formed, but another precisely similar may be constructed. In such cases a correct and scientific drawing will at one glance convey more useful information than could be done by long and laboured description. By means of his scale, compasses, and pencil, the mason, the bricklayer, the carpenter, or other artisan will be able to communicate his schemes to his employer, with infinitely more perspicuity and despatch than would be practicable by many sheets of writing. Nor is this so difficult as is supposed: for in plans of buildings, or representations of machinery, accuracy and not ornament are required: at the same time that neatness ought never to be disregarded. The mechanical draughtsman has occasion for plain and parallel rulers, compasses, black-lead pencils, Indian ink, hair pencils, and a drawing-board. Not only the outlines of regular objects may be correctly and truly drawn by the rules of geometry and perspective; but also the forms and intensity of shadows, in their different parts, may be laid down, by invariable rules, founded on the nature of the rays of light, according to which shadows of objects ought always to be represented, and not by guess, as is too often done in drawings otherwise scientifically correct. On this head satisfactory instruction will be obtained by consulting a work already recommended to the student, viz. *Nicholson's Principles of Architecture.*

Of Colours. The art of colour-making is properly a branch of chemistry; and is one of the most curious, though least understood, parts of that science. The principles on which colour-making

depends are entirely different from those on which other parts of chemistry are founded: and the practical management of the business being in the hands of persons whose interest it is to conceal their methods of working, it thence happens that there is no distinct theory of the business, and even scarcely a single good receipt, for making any one colour, hath yet been made public. The first general division of colours is into opaque and transparent. Opaque colours are those which when laid upon paper, wood, &c. or upon any other colour, cover them so completely that the colour of the ground entirely disappears. Transparent colours, on the contrary, leave the colour of the ground on which they are applied, visible through them. Of the first sort are white-lead, red-lead, vermilion, &c.: of the latter sort are the colours used for enluminating maps, &c. Another division is into oil-colours and water-colours. Most of those proper for use in water are also used in oil: but there is this remarkable difference that such as are perfectly dark or opaque, when mixed with water, become quite clear and transparent when made up with oil. This is particularly the case with those which have for their base the oxyde (calx) of tin, alabaster, or calcareous earth. The most perfectly opaque colours in oil are such as have for their bases lead, mercury, or iron: with the exception however of Prussian blue, which although its base be iron, is yet perfectly transparent when mixed up with oil. In water-colours those prepared from metals (the above blue excepted) are always opaque: but those drawn from vegetables or animals are transparent. Charcoal however, whether made of vegetable or animal substances, is always opaque in both water and oil. Another important division of colours is into true and false. True colours are those which, under every variety of circumstances, always retain their appearance, without change or fading; in which case they are said *to stand:* other colours either lose their appearance entirely, or gradually change into some other colour very different from that intended to be produced. What chiefly affects colours is their exposal to the sun in summer, and to the cold air in winter. To this however there is one exception; for white-lead, so much used in house-painting, when ground with oil, retains its whiteness when exposed to the weather, but soon degenerates to a brownish yellow if kept close. The proof of this may be seen in every room painted with white-lead: the parts against which tables, drawers, chairs, &c. are constantly placed, soon become yellow; while the other parts of the painting, fully exposed to the sun and air, suffer little change. In water white-lead is very apt to lose its colour, whether exposed to the air or not. It is particularly to be regretted that the most beautiful colours are in general the least durable: it is however to be expected that the fewer ingredients enter into the composition of any colour, or the more simple it is, the better will it resist the action of the air and light.

All colours, whether derived from animal or vegetable substances, must be extracted by either pure water or some other liquid: they cannot therefore be used in painting until the colouring

substance be united with some earthy or solid matter, capable of giving it a *body*, as it is called; and according to the nature of this matter will the colour be opaque or transparent. This matter ought to be pure white, that is, perfectly colourless, and quite unalterable by the weather or by acids and their opposite alkalies. Hence all earths are improper, being acted upon by acids; and most metallic substances however finely powdered and white, are apt to turn black by exposure to the air. The only substance to be chosen in preference to all others is the *oxyde* of tin, prepared either by fire or by the nitric acid (aqua fortis.)

[Although the reader will not expect, in this place a full explanation of the terms employed by modern chemists, yet it seems to be requisite to furnish him with the means of comprehending the meaning and qualities of certain names, operations, and substances, now universally used, in treatises on all branches of knowledge, which have any relation to chemical science.

The common or atmospheric air, formerly conceived to be a simple substance, and thence counted as one of the supposed four elements of which all terrestrial bodies were imagined to be formed, is now known to consist chiefly of two fluids or kinds of air, or vapour, or *gas*. Of these one is, by respiration, capable of supporting animal life: in it metals are calcined by fire, and combustible substances burn. The other gas on the contrary possesses qualities precisely opposite: for if breathed by animals it kills them; nor will it admit the combustion of bodies, nor the calcination of metals. The base of the first kind of gas is called *oxygen*, from two Greek words signifying to produce acidity or sourness, because one of the most general properties of this base is to form acids, by combining with different substances. When this base is united with *caloric* or the principle of heat, the combination is called *oxygen gas*, formerly called *pure or vital air*. The other component part of the common air which is extremely noxious and wholly unfit for breathing, is thence called *azotic gas*, from a Greek term signifying what is contrary to life. When any substance is burnt a decomposition of its parts takes place, and new compounds are produced. Heat and light are given out, and the combustible body attracts the oxygen from the air, by which means the azote is left at liberty. If sulphur, phosphorus, or charcoal are employed in the process of burning, these substances unite with the oxygen to form new bodies called acids: and it is not improbable that all other acids may be produced by the union of oxygen with some peculiar bases hitherto undetected. When a body has only a small quantity of oxygen united to it, not sufficient to convert it into an acid, it is called an *oxyde;* thus most of the metals can be reduced only into the state of an oxyde, by the union with oxygen; a process formerly called *calcination*, and the metal when thus reduced was called a *calx;* because it was reduced to a white powder by burning, in the same way with limestone, which in Latin is then called calx. When tin has been kept some time in a melted state over the fire, and is then exposed to the air, the surface becomes wrinkled and is covered with a grey pellicle: this is the

oxyde of tin. If this coat be removed the metal appears below in its natural brilliancy; but it soon, from the action of the air, becomes oxydated and loses its splendour. By continuing the process the whole tin may be reduced to an oxyde. The oxyde of tin may also be obtained by dissolving the metal in aqua fortis, that is, nitric acid diluted with water. A class of natural substances just the reverse of the acids is that of *alkalies*, so called from kali the Arabic name for a certain plant, in which the properties of this class of bodies abound. Alkalies have a peculiar taste, caustic or burning, they are incombustible and insoluble in water. They unite rapidly with acids, forming compounds in which the properties of both ingredients are lost. With flinty substances, and exposed to a great heat, they are converted into glass. They fit oils for mixture and union with water, as in the case of soap, a combination of the alkalies, potash, or soda, with oil or fat. When alkalies are mixed with various vegetable colours, they produce sensible changes on them: thus blue turns to green, red to violet, yellow to brown. Blue colours that have been made red by the mixture of acids, are again restored to blue by alkalies. On animal substances they exert a powerful burning quality called causticity: wollen cloth will, by a powerful alkali, be turned into a sort of jelly. The proper alkaline substances are soda and potash, which are called *fixed*, because they require a great degree of heat to dissipate or volatize them: the other is ammonia called *volatile*, because a very moderate heat is sufficient to make it fly off in vapours.]

——But to return to colours.—The oxyde of tin is so exceedingly fixed and refractory as to be quite unalterable, not only by alkalies or acids, by the weather or the sun, but even by the concentrated heat of a large burning mirror. It is besides extremely white and capable of being reduced to a powder of an extreme degree of fineness. For these reasons the oxyde or calx of tin is the most proper base of all fine colours. For coarse colours the white precipitate of lead, which is much less apt to turn black than white lead, may be used to advantage. After these remarks the general method of extracting colours from vegetable or animal substances, and fixing them by a proper basis, will be easily understood. For this purpose a quantity of oxyde of tin is to be procured, proportioned to the quantity of colour wanted. The oxyde must be well rubbed in a glass mortar, or one of Wedgewood's ware, with a little of the substance designed for brightening the colour, such as alum, cream of Tartar, spirit of nitre, &c.; after which it is dried and left for some time, that the union between the two substances may be as perfect as possible. If the colour is to be very fine, as for instance from cochineal, the colouring matter must be extracted with alcohol, (spirits of wine or pure spirit) but without heat. When the spirit is sufficiently impregnated with the colour, it is to be poured by little and little upon the oxyde, rubbing it constantly, in order to distribute the colour equally over every particle of the oxyde. The spirit will soon evaporate, leaving the oxyde coloured with the

cochineal. More of the tincture is then poured on, and rubbed; and at last a very beautiful colour, not inferior to the best carmine, will be procured, at a moderate expence. If instead of cochineal, we employ brasil-wood, turmeric, log-wood, &c. we obtain different kinds of red, yellow, purple &c. For coarser colours a decoction of the colouring bodies in water may be used, instead of alcohol: but as the water evaporates very slowly, very small quantities of the liquor can be poured at one time on the oxyde; so that the colour-making becomes very tedious. It is not improbable that this invaluable property of tin, in giving fixity and brilliancy to colours, particularly to scarlet and purple, may have been known to the antient Phœnicians, who resorted all the way to the southern parts of Britain, in the earliest ages of history for that metal. The tin they probably employed in secret, with some ordinary colouring-substance (perhaps some species of the cochineal insect) to give to the woollens of Tyre and Sidon the splendid purple or scarlet tint, so highly admired; but as being produced, as pretended, only from the liquor of a sort of shell-fish, so expensive as to become the peculiar and distinctive dress of the princes of the earth.

It is a common observation in chemistry that acids turn blue vegetable juices to red, and alkalies turn them green. It is equally true, though not so well known, that acids generally heighten red colours, so as to make them approach to scarlet or crimson. On the other hand alkalies tend to darken red colours, and bring them near to blue or purple. When mixed with yellows, acids constantly brighten them: but alkalies turn them to a dull orange. The nitric acid is found to heighten colours more than any other: and the vegetable acids are less powerful this way than the mineral. Thus if with a tincture of cochineal, either in water or spirits of wine, be mixed pure nitrous acid (spirits of nitre) the red colour will be changed to an exceedingly high orange or flame colour, which may be given even to cloth. If sulphuric acid (spirits or oil of vitriol) be employed, the colour will be turned to a full scarlet, inclining to crimson rather than to orange. With muriatic acid (marine acid or acid of sea-salt) the red is changed to the true crimson, bordering on purple. Alkalies both fixed and volatile, change the colour to a purple, which is brightest when the volatile is used. But these acids are all destructible by long exposure to the air; and alkalies still more so: colours prepared with them must therefore necessarily fade and finally disappear.

Having given these general notions of the theory of colour-making, it remains to specify the principal substances used with water or oil, in drawing and painting.

All the most essential parts of drawing may be obtained by the use of a black colour upon a white ground, as with Indian ink upon white paper. The introduction of other colours may however be of great use, on many occasions, where not only the forms and the lights and shades of objects, but their several natural colours and tints, are required to be exhibited to the spectator. For producing these colours and tints, various substances are

employed in drawing, when either originally liquid, or made so by mixing them with simple water, or with gum-water. Many of the same substances when prepared with oil are likewise employed in painting: the following brief observations on the principal colouring-substances will be applicable therefore to both branches of art.

The colours used in drawing may be arranged alphabetically under the general heads of black, blue, brown, green, red, white, and yellow.

1. *Black colours.* Indian, or more properly China ink, has been already mentioned. It comes from China where it is used for common writing, which in that country is performed with a pencil and not with a pen. The composition of this ink is unknown: but the colouring matter is said to be chiefly drawn from the black liquor found in the sepia or cuttle-fish. This ink is rubbed with water upon a tile or earthen plate, and can be made darker or lighter at pleasure. The best sort is stamped with Chinese characters; it breaks with a glossy fracture, and feels smooth and not gritty, when rubbed down in water, or against the teeth. A counterfeit sort made in this country may easily be known by its grittiness; being a composition of lamp or ivory black, ground up with gum.

Charcoal is used for sketching in the outlines of figures, in order to fix their proportions, before making a drawing with chalk. The best charcoal for this purpose is made of willow; it is cut into slips and the strokes may be taken out with a feather.

Black chalk resembles slaty coal cut into slips. It is commonly used in a brass or steel instrument called a port-crayon. This substance is much used in drawing figures, particularly from the life or from plaster-casts. It is more gritty but of a deeper black than black-lead, and without its glossiness. It is of two kinds, the French which is soft, and the Italian which is hard.

White chalk is also used together with black, for laying on the lights. It is much harder than common chalk; and instead of it tobacco-pipe clay is used.

Lamp-black is the soot of oil formed by burning: it stands well when used with either water or oil.

Ivory-black is the coal of ivory or bone, formed by giving them a gentle heat in a place where the access of air is quite excluded: the colour is deeper than that of lamp-black.

Blue-black is obtained by burning vine-stalks in a close vessel: it is like ivory-black with a tint of blue.

2. *Blue colours. Ultramarine* is prepared from *lapis-lazuli*, by calcining and washing it. *Lapis-lazuli* (meaning only the blue stone) is of a beautiful bright sky colour, sometimes mixed with white; it also contains pyrites which gives it the appearance of veins of gold. The powder stands perfectly well, and is consequently of the utmost value in every kind of painting: but its very high price prevents its general use.

Prussian blue is a combination of iron with a peculiar sort of acid. It produces an extremely beautiful blue colour, and stands

well: but to do this it must be properly prepared; for the common sort usually contains iron, which causes it to turn greenish.

Verditer is a blue colour procured from adding chalk or whitening to a solution of copper in aqua-fortis (nitric acid diluted with water;) the best is prepared by the refiners, by means of the copper dissolved in the process of parting silver from aqua-fortis. Verditer is only used for coarse purposes, chiefly by the paper-stainers, who commonly call it *sanders-blue*, a corruption of the French name *cendres blues*, or blue ashes.

Indigo. This colouring matter is obtained from several plants, and has some resemblance in its nature to fecula or starch. The indigo of commerce is chiefly procured from the *indigofera tinctoria*, a shrubby plant cultivated in the East and West Indies, for the purpose of extracting the colouring matter. When the plant is in maturity it is cut down and placed in large wooden vessels, where it is covered with water, and ferments. The water becomes turbid and of a green colour. According to the state of the plant the fermentation employs from 6 to 24 hours, when the liquid is poured into flat vessels, where it is continually agitated till blue flakes appear, which upon the addition of lime-water, fall to the bottom. The liquid is then poured off, and the substance in the bottom is collected in linen bags, through which the water drains away. When this substance is of a proper consistence it is formed into small cakes which are dried slowly in the shade. The history of indigo is curious: it was early known in India, whence it had its name among the Portuguese; for it signifies only the Indian dye: but its value was not understood in Europe before the middle of the 16th century: and then its use was either restricted or wholly prohibited, from a notion of its being injurious. In England it was prohibited from the time of Elizabeth to Charles II. In the edict relative to it, the indigo is described as a corrosive substance. In France dyers were allowed to use only a certain quantity of it. Indigo does not give so brilliant a colour as Prussian blue: but it is extremely durable. When dissolved in sulphuric acid (spirits or oil of vitriol) indigo forms Scott's liquid blue, used in colouring silk stockings, &c.

Smalt. When the mineral cobalt is oxydated and freed from its arsenic it is called zaffre. This melted with three parts of quartz or flint and one part of potash, forms glass of a beautiful blue colour, which when reduced to powder is called smalt. The blue employed with starch for linen, &c. is also made of this glass. Smalt is also used by the painters of earthen-ware and porcelain, and by enamellers. *Bice* is only smalt reduced to an extremely fine powder.

3. *Brown colours*. *Bistre* is the finer parts extracted from the soot of burnt wood; and is much used alone for sketches in water-colours, being a warm transparent colour.

Cologne-earth is a dark blackish brown mineral; although what is usually sold in the shops is an artificial mixture, and not really brought from Cologne in Germany: it is a very useful colour.

Umbre is a native ochreous earth, originally brought from Um-

bria in Italy: it is of a light brown when raw, and stands well. When burnt or calcined in the fire it acquires a fine rich deep brown colour, of great use.

4. *Greens.* There are few substances that are so useful as greens, in their simple state; so that artists in general produce their green colours by mixture of blue and yellow: and by varying the proportions of these colours any variety of green tints may be obtained.

Sap-green is the concrete juice of the buck-thorn berries: it is never used with oil; but in flower-painting or colouring prints &c.

Verdigris. Plates of copper exposed to the fumes of strong vinegar in the air will be converted into a green rust or oxyde called Verdigris. It is prepared in large quantities about Montpellier in the south of France, by laying alternate strata of copper plates and husks of grapes, while the vinous fermentation is going on, which soon grow acid, and corrode the copper. When they have remained in this state for some time, the plates are moistened with water, and exposed to the air, and the verdigris is scraped off. It is of a bluish green colour; but has no body and does not keep its colour well. *Distilled* verdigris is prepared from the common sort, by dissolving it in vinegar. This is of a very bright green, and is chiefly used for colouring maps, and in varnishes. It is perhaps unnecessary to observe that this colour, like every other produce of copper, is highly poisonous.

5. *Red colours. Lakes* are a class of colours formed by the combination of alum, and the oxyde or calx of tin, with the colouring matter of vegetables. The lakes used are chiefly reds, of different qualities according to the substances employed: the principal are carmine, Florence-lake, and madder-lake.

Carmine is a very rich bright crimson colour, and stands well when mixed up with water. In preparing carmine, 4 ounces of finely powdered cochineal are poured into 4 or 6 quarts of distilled water, that has been boiled in a *pewter* kettle, and then boiled six minutes longer. Eight scruples of Roman alum in powder are then added, and the whole kept on the fire one minute longer. When the gross powder has subsided, and the decoction is clear, it is carefully decanted into large glasses, where it remains covered over and undisturbed, until a fine powder settle down to the bottom, which is the carmine. The liquor is then poured off, and the powder is gradually dried. From the liquor the remaining colour may be separated, by the solution of tin, when a carmine is obtained, little inferior to the former.

Florence-lake is the kind generally used under the name of lake. It is a very beautiful colour in both water and oil, but it does not stand; and unfortunately no proper substitute for it is yet known. The best sort may be made from the sediment of cochineal, remaining in the kettle, after making carmine, adding a little cochineal, or Brasil-wood, and precipitating the colour by tin.

Madder-lake is not so bright and rich as the foregoing colours; but it stands much better: it is prepared much in the same way.

Rose-lake is generally called *rose-pink.* It is made on a basis of

chalk with the colour of Brasil or Campechy-wood. As it does not stand it is used only for house-painting or paper-hanging.

Vermillion is of a bright scarlet colour, formed by a combination of mercury or quick-silver with sulphur: when coarse, or in the ore it is called cinnabar. It ought to be of a very bright scarlet, inclining a little to a crimson hue. In oil it stands well: but in water it is apt to turn black.

Red-lead or *minium* is lead calcined in a strong heat till it acquire a red colour, by exposing it with a large surface to the fire. It is also made from litharge, which is a calx or oxyde of lead; but this colour is not equal to the first sort. Red-lead is apt to turn black in both oil and water, and is therefore used only in coarse works.

Indian-red is very useful, answering some of the purposes of lake, and keeping its colour. The genuine sort comes from India: but great part of what is sold is made in this country.

Venetian-red and *Spanish-brown* are mineral substances inclining to scarlet; but too coarse for any purpose but house-painting.

Burnt-ochre is the common yellow mineral heated in the fire till it become red: it is a very good and useful colour in both oil and water; and like all preparations of ochre it stands well.

Red-chalk is used as a crayon, for drawing on paper. It is much like Venetian-red, and often used in its room. It may be employed in oil as well as in water, and stands perfectly well.

Burnt terra di Sienna is made by calcining the raw Sienna earth till it become red. Being of a very rich tint, it is much used in drawing and painting, and keeps its colour well.

It is to be observed on this head of red colours, that red-ochre and Venetian-red differ in nothing from well-calcined colcothar of vitriol (green copperas heated till it melt and turn to a red powder.) The oxydes (ochres) of iron may be made to appear either purplish, or inclining to scarlet, according to the manner in which the calcination is performed. If the matter be subjected to an intense heat it becomes red: but the mixture of a small quantity of inflammable substance gives it a purplish cast. Hence various colours are sold under different names, which yet differ from each other only in the slight circumstances here mentioned: such are scarlet-ochre, Spanish-brown, *burnt terra di Sienna*. It is to be noticed that the oxydes of iron never show their colours until they become cold. Colcothar of vitriol while hot is always of a very dark dusky purple.

6. *White colours*. These are in general flake-white, white-lead, pearl-white, Spanish-white, egg-shell-white, &c. *Flake* and *white-lead* are the same substance differently prepared. A range of pots filled with vinegar are placed on tanner's-bark or horse-dung, to receive a moderate heat. On the pots are placed plates of lead full of holes. The acid vapour acts upon the lead and corrodes it, forming white-lead. Flake-white is only the finer parts of the same substance. These preparations of lead answer well in oil-painting: but in water, flake turns black, and should therefore never be used. Another more powerful reason exists for rejecting

all preparations of lead, notwithstanding their general usefulness in painting. Lead taken internally, even in a very small quantity, produces very violent and destructive effects on animals. As lead enters into the composition of enamels and glazing for porcelain and common pottery, the greatest caution ought to be employed in using those vessels, for holding any acid substances. Water has no action upon lead, unless the air have access to it, when a white crust is produced, as we see in cisterns or roofs of lead, which is the oxyde of lead. House-painters, who are not very particularly careful to keep themselves clean, are apt to contract distempers from the white-lead they use. Violent bowel-complaints, rheumatisms, even palsy itself, have frequently attacked persons exposed to the fumes of lead. The dreadful dry-belly-ache of the West Indies is attributed to the use of leaden vessels in household business.

To discover a proper substitute for preparations of lead in colours, particularly in house-painting many efforts have been made, by men of science, particularly in France: but hitherto so far without success that none has been found which can be furnished sufficiently cheap to become a substitute for white-lead. Pure carbonate of lime (limestone, chalk, marble) is very useful in water colours, and stands perfectly well. The white drawn by calcination from egg and oyster-shells, and Spanish-white, or common whitening, answers the same purpose.

Yellow colours. *Indian-yellow* is the brightest of all for water-colours, and is perfectly durable. It is said to be procured from the water of the buffalo. In India the natives use this material, to colour their callicoes, without any mordant to fix it, so the yellow is washed out every time the cloth is cleaned.

King's-yellow is refined orpiment, a mineral combination of arsenic with sulphur; it may also be procured by subliming these two substances together: it gives a very bright yellow, but does not stand well: great caution ought to be exercised in using it, as it is a powerful poison.

Naples-yellow is a preparation of lead and antimony, furnishing a very bright and durable colour.

Yellow-ochre contains an oxyde of iron: it is cheap and not very bright, but is valuable on account of its durability.

Dutch-pink is said, but probably erroneously, to be formed of chalk coloured with the juice of a certain French berry: it does not stand, and is of little value.

Massicot is an oxyde of lead produced by calcining white-lead: as the colour is not very bright, this substance is but little used.

Raw terra di Sienna gives a fine warm colour, and stands well. Yellow tints may also be drawn from turmeric, saffron, and other vegetables: but they are either feeble or so apt to change, as to be in general of little service.

The reader will have observed the terms *warm* and *cold*, employed in speaking of the application of colours in drawing and painting. These words are used metaphorically, in allusion to those objects in nature which excite in us the ideas of heat and